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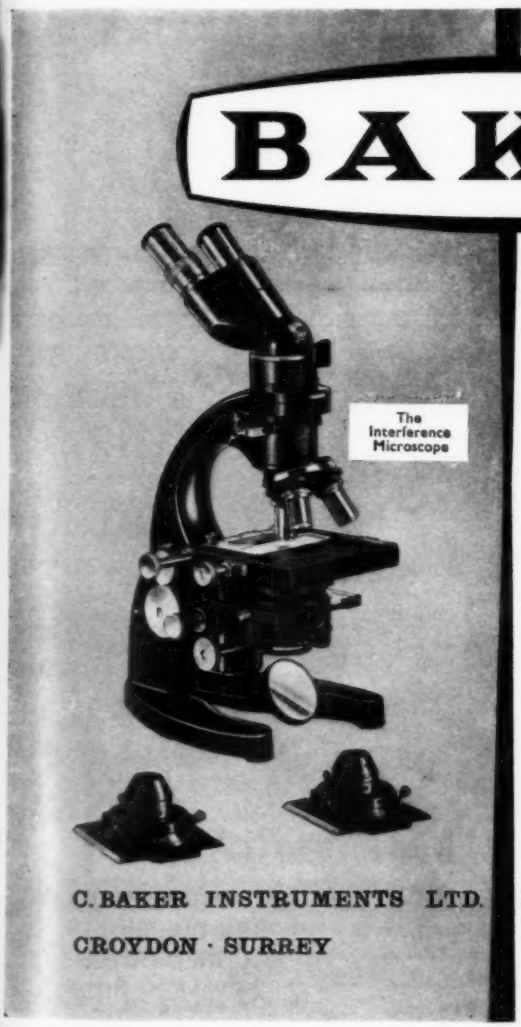

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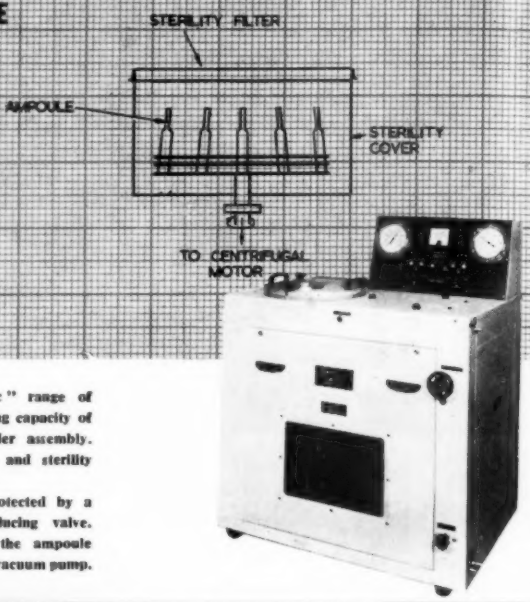

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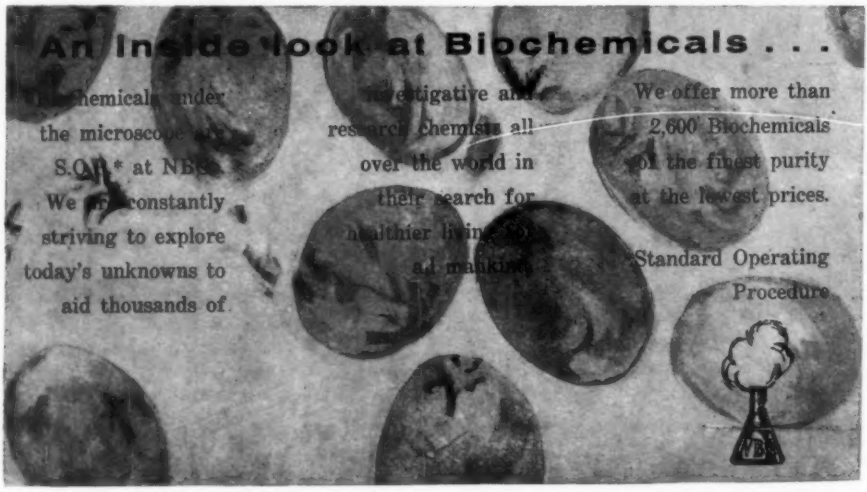
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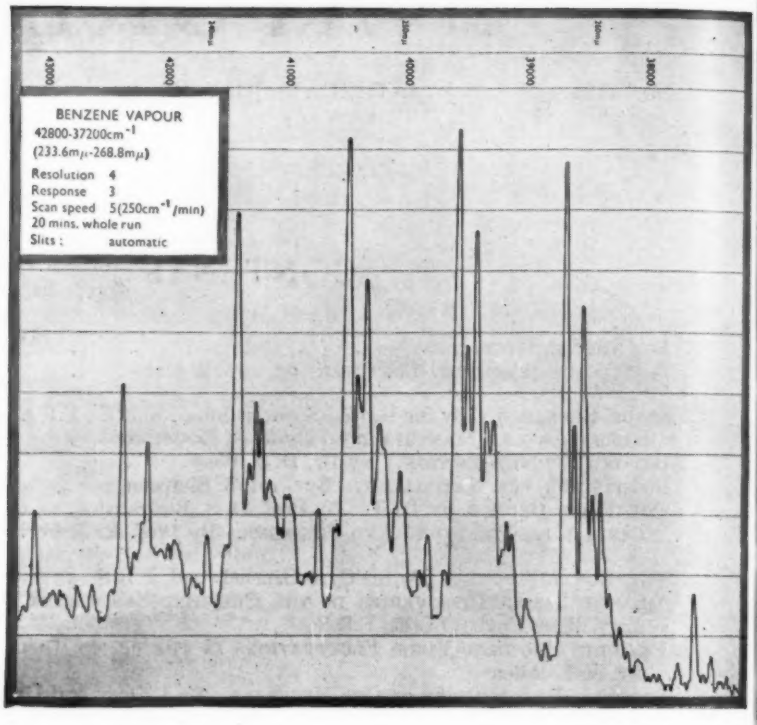

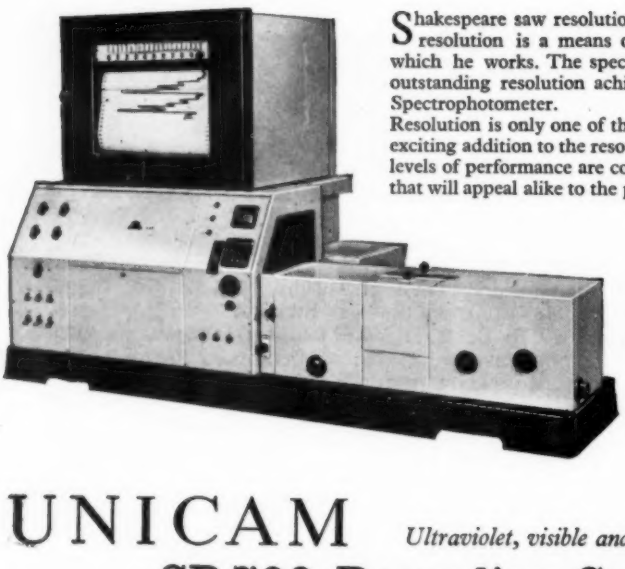

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THE ROYAL SOCIETY

"THE Royal Society of London for Improving Natural Knowledge", as the Society is described in its second charter of 1663, is celebrating the three hundredth anniversary of its foundation, and the presidential address by Sir Cyril Hinshelwood is printed in this issue (p. 274). Thus the Society is one of the oldest learned institutions in the world and is unique in its unbroken record of activity. During the years, its influence has varied in response to the circumstances of history, but it is worth emphasizing that even during periods of great national stress, such as the Napoleonic Wars, its Fellows were able to continue their investigations and even to correspond actively with, and to meet, scientific colleagues in other countries.

From its beginnings with private meetings in Oxford and London, the Royal Society has advanced, under a succession of distinguished presidents and officers, keeping in touch with current affairs, and steadily establishing the world-wide prestige in which it is now held. This curious combination of respect for the past and its gracious ways—the Society's present meeting room with the out-moded arrangement of the officers' seats is a case in point—with lively concern for modern topics, such as space research, is perhaps typical. The Society provides an outstanding example of adaptation or evolution in the conduct of human affairs.

It is not always realized how wide is the range of activity of the Royal Society in modern times. Thus it not only provides a forum for the discussion and publication of scientific papers, but also undertakes a number of public responsibilities. It is the 'adhering organization' for the United Kingdom with regard to the International Council of Scientific Unions and appoints delegates for meetings of the Council and of the several component Unions. This is done through national committees for the several subjects represented by the International Unions. On behalf of the Committee of the Privy Council for Scientific and Industrial Research, the Royal Society is responsible for the management of the scientific work of the National Physical Laboratory. It also takes an important part in the management of the affairs of the Royal Greenwich Observatory, and it is the custodian of one of the four copies of the Imperial standard yard and pound. The Society also appoints or nominates representatives to the governing bodies of the British Museum, the Spectator Committee, the Times Holding Company, and many scientific bodies, research institutions, schools, etc. In this way the Society is enabled to keep in touch with the changing scene, and also to give advice and counsel. A number of trust funds providing for research appointments are also administered by the Society. In addition, it is responsible for Parliamentary grants-in-aid for scientific investigations, for scientific publications and for international research associations and scientific congresses; these grants, some of which began in the 'fifties of the last century, have grown to substantial sums, and their use has proved to be of considerable importance, for example, for the publication of scientific papers, etc., not by the Royal Society alone, but through other channels. Incidentally, it may be noted that it is specifically provided that committees of the Society, except those dealing with the Society's domestic affairs and joint committees with other bodies, have power to suggest to the Council the names of additional members who may, or may not, be Fellows of the Society; and, in fact, many of the Society's committees include non-Fellows who are brought in for their special knowledge in a particular field.

The Royal Society now consists of some six hundred Fellows and foreign members. Broadly speaking, the fellowship is representative of the whole range of natural science. That this should be so is in part the result of the method of election. Candidates are proposed by Fellows on the basis of their scientific achievements. These nominations are scrutinized by the Council, which selects by ballot a limited number annually; at present the number is twenty-five. It is not always realized that in making its recommendations for election to the fellowship, the Council takes account of the general balance of subject interest among the Fellows; by this means it is ensured that all subjects are represented, and the domination of the Society by sectional interest is avoided. This form of election has been criticized, but it seems to provide the general balance of interest required. In addition, the Council has the power to nominate for election "persons, who . . . either have rendered conspicuous service to the cause of science, or are such that their election would be of signal benefit to the Society"; the numbers are, however, limited to one a year unless no election has been made in any year, in which case two nominations can be made in the following year. Foreign members are nominated from time to time on the grounds of the eminence of their scientific attainments, but not more than four can be elected annually. Ordinary fellowship of the Society is limited to British subjects and citizens of Eire. Women were tardily admitted to the Society under a curious statute which reads: "Nothing herein contained shall render women ineligible as candidates".

Human institutions which have survived for three hundred years are sufficiently rare in these days of continual and ever-increasing pressure of events to be worthy of special comment. The present high esteem in which the Royal Society is held throughout the world is due in part to the eminence of its Fellows, and in part to the wisdom with which it discharges its responsibilities to science and to the nation. It can now enter on a further century of endeavour, adding to the reputation which has been steadily built up over the years, and sustained by the good wishes of scientists throughout the world.

THE UNDER-DEVELOPED COUNTRIES OF THE WORLD

THE International Development Association Bill, which received its second reading in the House of Commons on March 29 and Royal Assent on June 3, was introduced to enable the United Kingdom to accept the Articles of Agreement of the proposed International Development Association, the text of which has been published as a White Paper*; the articles were previously approved by the executive directors of the International Bank for Reconstruction and Development for submission to Governments. The main provisions of the new Act concern the payment of the United Kingdom's subscription to the Association, which is an affiliate of the International Bank, its parent organization, and over a period of years this subscription will amount to nearly £47 million in convertible sterling. This subscription is the largest, next to that of the United States, which is responsible for 320 million dollars out of the total 1,000 million dollars, and, like the other subscriptions, is roughly proportional to the subscription to the International Bank.

In introducing the Bill on March 29, the Economic Secretary to the Treasury, Mr. A. P. L. Barber, explained that these subscriptions were related first to the economic position of each country, so as not to press too heavily on the less-developed countries, who would have to join in order to be eligible for finance from the Association. Secondly, the schedule of potential members is divided into two parts: those in Part I are the industrialized or more-advanced countries, which will pay the whole of their subscriptions in gold or freely convertible currencies, whereas the less-developed countries listed in Part II will pay only 10 per cent of their initial subscription in gold or freely convertible currency, and the remainder in their national currencies. This portion the Association will not be free to convert into other currencies or to use to finance purchases of exports without the consent of the country concerned. On the other hand, 90 per cent of the subscriptions from the countries in Part I may be paid in the form of notes not bearing interest and cashable at par on demand by the new Association. About £11 million of the United Kingdom's subscription will be payable in the first year and about £9 million in each of the following years.

With the Articles of Agreement, the White Paper to which Mr. Barber referred includes an accompanying report of the executive directors of the International Bank, dated January 26, 1960, which emphasizes that the Association is intended to finance further development in the less-developed areas of the world included within the Association's members; and while the Association is given wide latitude, such financing is intended to be for purposes which are of high priority for development in the light of the needs of the areas concerned and, except in special circumstances, for specific projects. Moreover, finance is not to be provided by the Association if, in its opinion, such finance is available on reasonable terms from private sources or could be provided by a loan of the type made by the International Bank. Article I, in fact, defines the purposes of the Association as to provide economic development, increase productivity and thus raise standards of living in the less-developed areas of the world included within the Association's membership, particularly by providing finance to meet their important developmental requirements on terms which are flexible and bear less heavily on the balance of payments than those of conventional loans.

The Association is thus intended to further the developmental objectives of the International Bank for Reconstruction and Development and to supplement its activities. As Mr. Barber explained in the House of Commons, the International Bank itself is not designed to help countries with sound and important development projects which they are unable to finance simply because of the weakness of their balance of payments. The new Association will be empowered to lend in such cases on special terms which may, for example, include a long period of repayment, or a period of grace before repayment commences, or even waive interest for an initial period. Apart, however, from being complementary to the work of the International Bank, Mr. Barber pointed out that linking the Association with the Bank is also a matter of confidence and will enable the Association to operate as a going concern from the start.

In commending the Bill to the House of Commons, Mr. Barber also referred to the considerably enlarged part Great Britain is now playing in providing assistance for overseas development; but our capacity to do more, he said, is inevitably limited. The commitment to contribute to the International Development Association had been foreseen for some time, and the Government has decided to give priority to this measure to supplement the existing operations of the International Bank and to increase the united funds available for development. This point of view was generally welcomed in the House of Commons, although Mr. H. A. Marquand and some other speakers questioned even so whether enough is being done for the under-developed areas.

Mr. Marquand referred particularly to the White Paper, "Assistance from the United Kingdom for Overseas Development"*, also mentioned by Mr.

* International Development Association. Articles of Agreement as approved for submission to Governments by the Executive Directors of the International Bank for Reconstruction and Development on 26th January, 1960; and Accompanying Report of the Executive Directors dated 26th January, 1960. Pp. 26. (Cmnd. 965.) (London: H.M. Stationery Office, 1960.) 1s. 3d. net.

* H.M. Treasury. Assistance from the United Kingdom for Overseas Development. Pp. 20. (Cmnd. 974.) (London: H.M. Stationery Office, 1960.) 1s. net.

Barber which sets forth both the growth and the present magnitude of this effort. From £61 million in 1951–52, after a decrease to £49 million in 1952–53, this has increased, apart from a slight recession in 1956–57 and 1957–58, to £110 million in 1958–59 and an estimated £138 million in 1959–60. The bulk of this takes the form of grants, loans and payments for technical assistance under arrangements made directly with the recipient country, totalling £86·1 million and an estimated £117·7 million in 1958–59 and 1959–60, respectively, compared with £23·4 million and an estimated £20·7 million in contributions to international bodies working in this field.

Under the former, described as bilateral assistance, is included that given to the Colonial territories, for which altogether some £220 million was made available under the Colonial Development and Welfare Acts during the period 1946–60; of this total, about £45·5 million was unspent by March 31, 1959. Subsequent legislation has provided an additional £95 million for the period up to March 31, 1964, and of the figures already quoted for 1958–59 and 1959–60, £49·4 million and an estimated £62·7 million are for the Colonial territories, £26 million and an estimated £40·6 million for the independent Commonwealth countries and £10·7 million and an estimated £14·4 million for other countries. These figures include a considerable contribution to education, though such expenditure is not distinguished separately in the White Paper, and contributions to technical assistance totalling £4·4 million in 1958–59 and an estimated £5·2 million in 1959–60.

This technical assistance may be provided for Colonial territories through the Colonial Office, and to independent countries of the Commonwealth and to other countries under arrangements made direct, under the Colombo Plan, and through the Foundation for Mutual Assistance in Africa South of the Sahara and the Central Treaty Organization. For example, the cost of training 473 out of 2,181 officers in the public services of the Colonial territories, who in 1959 attended training courses in the United Kingdom, was met from Colonial Development and Welfare Funds, and in the past five years the Post Office has trained more than 1,000 people from overseas in postal, telephone and telegraph operations and in telecommunications engineering. The White Paper refers also to the work of the Overseas Research Council and of the various advisory bodies on Colonial Research without, however, giving any estimate of expenditure on scientific research in this way.

When private investment of about £100 million is taken into account, the White Paper estimates that about 1·25 per cent of the national income of the United Kingdom goes to benefit the less-developed countries, and since the War some £2,500 million has been devoted to those countries from United Kingdom sources in the form of private investment and Government assistance. Such assistance can only be provided if the economy of the United Kingdom continues to develop on the right lines, and the Minister of State for Commonwealth Relations, Mr. C. J. M. Alport, was at pains to stress this aspect in winding up the debate from the Government side. Incidentally, it should be noted that, as Sir Henry d'Avigdor-Goldsmid pointed out in the debate, the Association is specifically empowered to provide technical assistance and advisory services at the request of a member, and such assistance may, at the discretion of the Association, be provided with or without reimbursement.

The brief debate when the Bill received its second reading in the House of Lords on May 17 followed rather different lines. In introducing the Bill for the Government, the Earl of Dundee said that the United States and Japan have already introduced legislation to provide for the adherence of their countries to the Association, and pointed out that the Bill is only part of a general effort to assist the more-undeveloped countries of the Free World. He also suggested that it is more scientific to measure our effort as a percentage of our exports rather than of our national income; that figure is about 7 per cent and not 1·25 per cent. He also quoted the reference in the communiqué from the Conference of Commonwealth Prime Ministers to the desirability of co-operative action among members of the Commonwealth in assisting the economic development of Commonwealth countries in Africa which have recently attained or are approaching independence. Indeed, the Conference had recognized the urgent need to maintain, and where possible increase, the flow of economic assistance to the less-developed countries and had specifically welcomed the decision to establish the International Development Association.

Lord Ogmore, in welcoming the Bill, stressed particularly the importance of technical assistance, and in this connexion he said that in his experience in the past few years one of the greatest shortages in the under-developed countries had been in competent managers. They are short also of people with technical experience at the professional and the technician-level, and this could greatly affect the execution of a scheme; he was glad that the Government has already recognized the importance of technical training for apprentices. In his reply for the Government, the Earl of Dundee directed attention to the powers which Sir Henry d'Avigdor-Goldsmid had noted in the House of Commons.

The bearing of the International Development Association on technical assistance is not the only reason why the new Act merits some attention from the scientist and technologist. Finance is not the sole consideration which determines the possibility of particular schemes. Both the debates in Parliament and the White Paper on Assistance from the United Kingdom indicate how complex have now become the relations between the overseas territories and the Colonial Office and the Office of Commonwealth Relations. These relations have not been adequately debated, but with the increasing number of Commonwealth overseas territories which have attained or are on the verge of independence, strong arguments can be advanced for reviewing the relations between the Colonial Office and the Commonwealth Relations

Office, if not of the Foreign Office also. It might well be that merging of the Colonial Office with the Commonwealth Relations Office in a new single Commonwealth Office could provide a constructive solution to numerous existing difficulties, including not merely those of relations with the newly independent territories, but also some of the problems of overseas service, which may, in fact, largely determine the availability or not of the professional assistance required in many schemes of technical assistance.

The establishment of the Overseas Research Council was, in fact, a move in the right direction; but more may be required if the work of the Council is to be fully effective and if technical assistance is not to be hindered by man-power problems. In the first place, however, there is undoubtedly need for clear thinking as to the structure most appropriate to the new conditions; that structure must take account both of professional service problems and of the national instincts of the newly independent countries, to which attention was rightly directed in the debate on March 29. It must be one which fully respects legitimate national pride and aspirations, and yet assists them to achieve administrations which are free from external control, and eliminate opportunities for bribery and corruption.

The other reason why scientists and technologists should be concerned with this question of assistance to under-developed countries, whether in the technical field or otherwise, appears in a talk, "The Coming Attack on World Poverty", broadcast by Mr. A. Shonfield and printed in *The Listener* of March 3. Sir Henry d'Avigdor-Goldsmid recognized the importance of the new Association, provided its resources are wisely used, in the war for men's minds; and Mr. Marquand, who is clearly anxious for a world attack on such problems, including help from the Communist countries also, referred to Mr. Hoffman's calculation that between 15,000 and 20,000 million dollars would be needed over the next ten years by way of help to the under-developed countries. Nevertheless, neither sounded the note of urgency which characterizes Mr. Shonfield's talk, and which is derived largely from the changes in conditions which are the direct result of the application of science; and the Articles of Agreement of the Association merely link mutual co-operation for constructive economic purposes and development of the world economy with the maintenance of peace and world prosperity and acceleration of economic development in the less-developed countries with the interests of the international community as a whole as well as the interests of those countries.

Mr. Shonfield, in fact, urges that we have reached the point of crisis; he thinks that unless the productive power of the under-developed countries is much increased during the next few years, the standard of living in some places may even recede from its appallingly low present level. Even if this is avoided, it will be much more difficult to bring the under-developed countries to the stage where they can advance rapidly on their own initiative in the 1970's or 1980's, and this apart from the risk of them becoming Communist States in the meantime. This, Mr. Shonfield believes, would be a further obstacle, for he is convinced that the West could give these countries the fruits of modern technology more quickly than they could possibly obtain them otherwise.

Mr. Shonfield is optimistic as to the generosity of the West, but he is very realistic as to the sustained good sense that will be required and the readiness to compromise, at least in the early stages of development, with many of our cherished ideals and standards. The International Development Association is indeed a welcome step forward, but much more will be required. Apart from constructive thinking about the whole structure of government as it affects the conditions of service and operation, there must be real determination to use to the full all existing instruments such as the Colonial Development Corporation and the Overseas Research Council.

SPACE RESEARCH

Satellites and Scientific Research

By Desmond King-Hele. Pp. xii+180+6 plates. (London: Routledge and Kegan Paul, Ltd., 1960.) 21*s*. net.

THE launching by the U.S.S.R. on October 4, 1957, of the first artificial Earth satellite may be said to have opened the era of outer-space research. Subsequent developments have been rapid. The second *Sputnik* was launched by the U.S.S.R. on November 3, 1957. The first successful launching of a satellite by the United States occurred on February 1, 1958. Since then the Americans have successfully launched several more satellites. In addition, space vehicles (*Luniks*) have been launched by both the Russians and Americans, some of which will orbit the Sun and may be termed artificial asteroids. The Russians have succeeded in hitting the Moon with one of their *Luniks* and transmitting a photograph of the back face of the Moon by another.

This book is concerned solely with the artificial satellites, the equipment installed in them, the purposes for which the equipment was designed, and some of the scientific results that have been derived. The preface is dated April 1959, only 18 months after the first successful launching of a satellite, though mention is made in the text of the launching of the three American satellites, *Explorer* 6 on August 7, 1959, and *Discoverers* 5 and 6 on August 13 and August 19, 1959, respectively. Brief reference is also made to the launching of two space-vehicles, the Russian *Mechta* or *Lunik* on January 2, 1959, and the American *Pioneer* 4 on March 3, 1959.

A satellite can provide scientific information in two ways. In the first place, careful tracking of the orbit of the satellite and of the changes in the orbit with time can provide information in two directions. The equatorial bulge of the Earth causes the orbital plane to rotate slowly about the Earth's axis, in the opposite direction to the satellite's motion. From the analysis of these changes in the orbital plane, the ellipticity of the Earth's figure can be derived and also some information about any asymmetry of the Earth

about its equator. The drag of the atmosphere on the satellite produces progressive changes in the shape of the orbit, the distance of the satellite at apogee decreasing more rapidly than the distance at perigee, so that there is a progressive reduction both in the orbital period and in the eccentricity of the orbit. From the changes in the shape of the orbit information about the density and temperature of the upper atmosphere at different heights can be inferred. The information that has already been derived from the study of these orbital changes, to whose analysis the author of this book has made substantial contributions, has substantially modified previously accepted ideas. This information is independent of any instrumental equipment carried in the satellite.

In the second place, each satellite is provided with instrumental equipment designed to obtain information in specific directions from coded signals telemetered to the Earth. Some striking and unexpected information has already been obtained, though more information will become available when the signals have been fully analysed.

The value, f, of the ellipticity or flattening of the Earth, that has already been derived from the satellite data is $1/f = 298{\cdot}20 \pm 0{\cdot}03$. The value previously accepted, derived from geodetic data and from the analysis of changes in the Moon's orbit, was 297·1. The change is substantial; the previously accepted value was based on many investigations, which had given reasonably accordant values. It is also tentatively inferred that the Earth is slightly asymmetrical about its equator (slightly pear-shaped), the north pole being about 50 ft. higher and the south pole about 50 ft. lower than on a spheroidal earth. This conclusion is not yet definitely established; further observations will eventually lead to a more accurate result. It is to be expected that higher terms in the gravitational potential field of the Earth will in course of time be evaluated, when data from a number of satellites with differing orbital inclinations have become available for analysis.

The analysis of the changes in the shape of the orbits has led to the definite conclusion that the density of the atmosphere decreases more slowly with height than had previously been believed, largely from the extrapolation of data provided by rockets. At heights of 120–250 miles, the atmosphere is 3–11 times more dense than was previously believed. The inferences about the temperature of the atmosphere at these and greater heights are as yet only tentative, though it appears that at great heights the temperature is considerably higher than has hitherto been supposed. There is also some evidence that the air density at heights of 100–500 miles varies with a period of about 27 days, being presumably influenced by solar activity.

The most striking discovery so far obtained from the instruments carried by satellites is the existence of two belts of hitherto unsuspected intense radiation around the Earth which are attributed to charged particles trapped by the Earth's magnetic field. Much more information will in the course of time be obtained about these belts, their nature and their changes. It is thought that the inner belt may be caused chiefly by cosmic-ray debris and be composed mainly of protons, while the much larger outer belt is fed by particles from the Sun and is composed mainly of electrons. The further study of these belts will provide information about the aurora and about the Earth's magnetic field.

Such wide interest has been aroused by the launching of satellites and space probes that this book, describing how and what information has been derived from satellites, is very timely. It is written so far as possible in non-technical language, and is well illustrated with many figures. The author has given an extensive list of books and scientific papers relevant to each chapter, which will be of use to those who wish to obtain further information on any of the subjects discussed in the book.

H. Spencer Jones

CYBERNETICS AND MANAGEMENT

Cybernetics and Management

By Stafford Beer. (Management Science Series.) Pp. xviii+214. (London: English Universities Press, Ltd., 1959.) 25*s*. net.

IT is a sign of the importance of cybernetics that eleven years after Weiner defined the study of control mechanisms as a new discipline, inquiries about its nature and utility have become more topical and not less so. In directing his contribution on this topic to the "scientifically educated and imaginative manager", Beer recognizes that such interest extends well beyond academic halls.

Approaching a brief answer to the general question, Beer says the importance of cybernetics derives from the backwardness of the concepts of 'control' that prevail in our society. For cybernetics, control is an attribute of system function, an attribute that may be produced by diverse and sometimes quite subtle means. The diversity of their controls makes biological systems valuable models for industrial cybernetics.

In industrial application, cybernetics is not solely concerned with automation on the assembly line. Indeed, its main target is managerial: a control device, seeking optimal strategies, amplifying the intelligence of its human components, learning from experience and adapting itself to its environment. The 'device' is quite general, includes not only computers and other hardware but also methods of organization, of fact finding and of decision making that involve human agents. Present managerial methods, with all their various components, are instances of such systems. Moreover, because they show goal-seeking behaviour and attempts to maintain equilibria against varying disturbances, they belong to the general category of 'homeostat' that includes many biological systems as well.

Its jacket describes this book as a presentation of the basic principles of cybernetics without a mass of mathematics. Such a presentation it certainly contains, and delightfully clear it generally is. In places, however, a surfeit of detail and perhaps a few tracks of hobby horses tend to obscure the main trail of the description. Nine pages of preface and seven pages of connective summary, possibly designed to rectify this 'noise', will aid the selective reader to follow the main thoughts. In his role as a philosopher he will be well rewarded.

For the reader as a manager the value of this doctrine is not so clear. He will regard this as the second major move in fifteen years to construct a managerial science. The sphere of the first, operational research, was more limited than that of industrial cybernetics. It functioned within, as part of,

the control system that is under study by Beer's cybernetics. The author recognizes that the cybernetic is the second serious attack on managerial science, but maintains that there is room for both. To him, operational research is the study of complex probabilistic systems whereas cybernetics deals with exceedingly complex systems of this type (which is not a generally accepted definition). There is a possibility that the representative manager may feel he is being attacked by exceeding complexity.

On the other hand, Beer's clear prose offers novel modes of thought which may well clarify some managerial problems. For example, the concept of the industrial system as a 'homeostat' is certainly convincing and ought to provoke new ideas. A fresh way of viewing old material is also provided by the notion of the 'fabric' of a machine, which implies that organic as well as inorganic material may be regarded as operating mechanically. These and other ideas Beer presents, indeed cybernetics as a whole, may best serve management by stimulating thought, "in other categories" about problems of control. Creative thinkers know that this is no mean gift.

As serious reading for the intelligent layman and even as light reading for the cybernetics student, this book will prove stimulating.

J. A. Easterbrook

BEYOND SCIENCE FICTION

Human Potentialities

By Dr. Gardner Murphy. Pp. x+340. (London: George Allen and Unwin, Ltd., 1960.) 25*s*. net.

PHILOSOPHERS nowadays seem to have replaced the angels on a needle point by semantic wrangles, and working scientists lack the courage to look beyond the confines of their professional competence. Speculations upon man's place in the cosmos, or upon the prospects of changes in human nature, are generally left to woolly-minded mystics or second-rate intellects. Gardner Murphy's thesis brings to bear upon these neglected topics the full weight of a lifetime of scientific scholarship, coupled with a facility for imaginative and constructive thinking. In re-presenting these age-old questions in the light of modern research findings in biology, sociology and psychology he succeeds in challenging one's complacent assumptions with startling new perspectives.

The commonly accepted scientific view of human nature has a somewhat depressive flavour. Personal motivations seem tied to primitive drives, and social progress is limited by rigid rules of group thinking and by the increasing pressure to uniformity of our mechanical technocracy. But these aspects may not constitute the whole truth. Certain human attributes may be no more explicable in terms of visceral drives than are the properties of chemical compounds describable in terms of their constituent elements. Dr. Murphy argues that the processes of sensory exploration and of learning, although originally subservient to visceral needs, become satisfying ends in themselves leading to a whole new system of motivations. New motivations lead to new ways of human interaction and whole new dimensions of human nature that could not have been foreseen or deduced. He thinks the writers of science fiction fall short because they merely extrapolate existing trends and take no account of the changes in man himself which allow of new dimensions of interaction with the environment. The world of the ancient Greeks or of the contemporary 'organization man' are something more than mere extensions of the habits of our simian ancestors. As he puts it rather colourfully at one point (p. 308): "If it is katydid nature to scrape, frog nature to croak, warbler nature to warble, it is human nature to play the *Air for G String*". The potentialities of human nature must lie beyond the limited historical and social expressions of it that we know at present.

In putting forward his plea for the larger view of human nature, Dr. Murphy takes fully into account the evidence of our grosser individual limitations. He dwells at length on such matters as the development of fixed habits of thinking and perceiving which blind the individual to culturally unpopular viewpoints. Although the increasing tendency to standardization of thought and feeling in modern society clearly threatens to stifle creativity, he gives reasons for hoping the creative urge may win through.

In the field of genetics, for example, he points out that the scope for evolutionary change is greater than is generally appreciated. Concentration on the effects of pathological genes has diverted attention from the inheritance of variations of temperament, and from the possibilities of readier manifestations of particular attributes in particular environments. Some stocks may be increasing in numbers and others decreasing so as to alter the predominant temperamental patterns of the group. Qualities of sensitivity and of equanimity could be gaining at the expense of toughness and aggressivity. Just as height is increasing (perhaps due to favourable environment and especially nutrition) so may be capacities of learning and intelligence.

In his more far-reaching speculations Dr. Murphy seems to imply that highly organized groups develop a life of their own beyond the individual personalities involved. Artistic and scientific achievements ultimately become impersonal or interpersonal. In the findings of telepathy research, it appears as if the individual consciousness reaches out so that the boundaries between mind and mind or between mind and the environment become blurred.

Scorning the traditional timidity of the social psychologist in the face of value systems and judgments, Dr. Murphy plunges into discussion of political systems. He sees the present day as a period of crisis in which man may destroy himself in atomic conflict before intelligent control of social development becomes possible. For the immediate future the most hopeful prospect seems to be a rapid economic development. In this the West may overtake their opponents, who will end up by capitulation or imitation, or the two camps may both progress so fast that their leaders can allow peaceful competition between the two systems for some time to come. If this respite is allowed us, then humanity will have time to choose between such possibilities as an authoritarian hierarchy or a leaderless, group-centred life on the ant-hill model. Among these long-range prospects he sees the greatest hope of a viable civilization in some system in which the governing forces are reliably guided by intelligent feed back from the middle and lower levels. Any such system would call for revolutionary development of education, and also freedom to indulge individual artistic and cultural interests beyond the immediate needs of the corporate technocracy. At present education tends to be too didactic, geared too closely to the task of imparting technical skills, instead of encouraging creative

thinking and discussion among the young on out-of-school family and community problems.

Because of the range and complexity of the problems discussed this book cannot be digested quickly nor reviewed comprehensively. But it is well worth studying from cover to cover. D. J. WEST

FOSSILS FOR THE NATURALIST

Fossils

By Prof. H. H. Swinnerton. (The New Naturalist: a Survey of British Natural History.) Pp. xiv+274+25 plates. (London: William Collins, Sons and Co., Ltd., 1960.) 30*s*. net.

THE volumes of Collins's New Naturalist Series are delightfully produced books, splendidly illustrated and written by acknowledged authorities. They make ideal presents, and are a delight to possess. It is also true that most naturalists are born collectors; and these books are eminently collectable. But these facts do not alone explain the success of the series. It succeeds because these books are mostly written by naturalists for naturalists. They appeal to the faculties of wonder and delight in Nature which (rather than the spirit of curiosity and the pure desire for knowledge) are the particular characteristic of the naturalist. The present volume, the forty-second of the Series, is no exception. It is in the direct line of descent from Hugh Millar and is a naturalists' book and not just another popularization of science.

Prof. H. Swinnerton's approach to his subject is historical in two different senses. He is most successful in conjuring up pictures of the successive extinct faunas and floras in which the animals and plants are brought vividly before us as living things in their changing natural environments. We follow in separate short chapters the evolution of the main phyla of plants and animals, first in the Palæozoic, then in the Mesozoic and finally in the Cainozoic. At the same time, by a series of cleverly interwoven digressions, we learn of the history of the growth of palæontology, and our interest is cunningly sustained by stories of the lives of many of the collectors and research workers whose discoveries he describes. It is all very well done, and the book is eminently readable.

All this being said, it is the more unfortunate that an unqualified welcome cannot be given to this book which at first sight seems so well to fill an obvious gap in the New Naturalist Series. It is not that the vividness of the reconstructions of the geological past is often obtained by the presentation of detail the conjectural nature of which is not made sufficiently apparent. Nor, since the book is not intended for palæontologists, does it matter much that a number of names used are out of date, as are also some of the ideas (for example, the derivation of *Caninia*, *Palaeosmilia* and *Dibunophyllum* from '*Zaphrentis*' in the Lower Carboniferous, and other ideas about the evolution of corals and graptolites). The pity is that there are a number of confusions of matters of some importance.

Thus it is regrettable that the graptolite zooid is described as possibly not unlike a hydroid polyp, while the dendroid graptolites are said to be comparable with *Cephalodiscus*. It is also unfortunate that the old classification of the East Anglian crags in the Pliocene is retained, especially as confusion is created by the remark that the deposits underlying the Cromer Forest beds have been shown to be of Pleistocene age. This particular confusion is worse confounded by the caption to plate 21, "Marine Fossils of the Quaternary", which illustrates both crag and Eocene fossils. Presumably for Quaternary, Cainozoic should be read. Other confusions are of serpulite (*Salterella*) with *Serpula*, the alleged presence of *Archaeocyathus* in Scotland and the inclusion of the reindeer in a list of extinct animals.

The illustrations are, with one or two notable exceptions, well chosen and well reproduced. However, there are several illustrations where a number of fossils are represented on very different scales without any indication of the relative or absolute size of the specimens. Finally, it is necessary to say that there are far too many misprints, and that these chiefly affect the descriptions of the plates (at least fourteen corrections required). S. SIMPSON

THE FIRST DECADE OF DDT

DDT

The Insecticide DDT and Its Significance. Edited by Paul Müller. Vol. 2: Human and Veterinary Medicine. By W. J. Hayes, Jr., S. W. Simmons and E. F. Knipling. Edited by S. W. Simmons. (Lehrbücher und Monographien aus dem Gebiete der Exakten Wissenschaften, Chemische Reihe, Band 10.) Pp. 570. (Basel und Stuttgart: Birkhäuser Verlag, 1959.) 66 Swiss francs; 66 D.M.

THIS second volume of a series on DDT contains three contributions by American authorities on insecticides and their use: "Pharmacology and Toxicology of DDT", by W. J. Hayes, jun.; "The Use of DDT Insecticides in Human Medicine", by S. W. Simmons, and "The Use of DDT in Veterinary Medicine", by E. F. Knipling. The first two of these are almost equal in length and comprise about 400 pages of the book, each concluding with a list of some 600 references; the shorter veterinary section has about 200 references.

Dr. Hayes deals first with clinical, pathological and physiological aspects of DDT toxicity as observed in animals. Human toxicity risks are then discussed from data on experimental and accidental intakes by man, on workers handling DDT, and in relation to DDT residues accumulating in water, in milk or in foodstuffs derived from treated animals or vegetable sources. This is summed in terms of administrative policies for toxic residues in general in consumable goods. DDT is safe when used as recommended. Hazards to domestic mammals, birds and insects (bees notably) and to various forms of wild life from medical and veterinary usages of DDT form concluding chapters to the section.

The contribution by Dr. Simmons (also editor of this volume) is not merely about DDT for the control of arthropods of medical importance. It is valuable and noteworthy for its emphasis, well illustrated graphically, on the effects of vector control by DDT on the incidence of the diseases concerned. Much of this part of the work is about mosquito-borne infections and mainly on malaria control, arranged geographically. Other chapters are on other biting flies, houseflies, lice, fleas, triatomid bugs and on the mites and ticks. The acarines are less susceptible to DDT than the insects. It seems scarcely justifiable, in view of general experience and what is recorded in the relevant text, that, for example, scabies and

scrub typhus due to mites should be included in the way they are among the diseases listed at the beginning of this whole section as controllable by DDT. Cockroaches, bed bugs and other troublesome creatures are dealt with in a chapter on pests.

Dr. Knipling, on veterinary applications, first recapitulates briefly the essentials of DDT toxicity to stock. Formulations are then compared, and special techniques for spraying and dipping are outlined and illustrated by numerous photographs throughout the text. There is some overlap inevitably with the medical field, but here is found the more extensive exposition of DDT in tick control, and for controlling various biting insects, blowflies, myiasis flies, lice, fleas, mites, exclusively or primarily of veterinary concern. Indications of insecticides more effective than DDT for certain arthropods are clearly set out.

What might well have been indicated clearly in the title or introduction to this book is that, although published in 1959, its subject-matter is not covered beyond 1954. The basic problems of toxicology being by then well clarified for DDT, this aspect is not greatly affected by the time lag. But DDT-resistance in some insects, notably houseflies, had compelled the use of alternative insecticides in some parts of the world well before 1954. This is, of course, brought out in the presentation of the medical section, and Dr. Simmons also focuses attention on the problem by concluding with a general appraisal of DDT-resistance, as it existed by 1954, with comment on possible prospects. Much newer work on DDT-resistance and on resistance to other contact insecticides is, inevitably, not embodied in this book. Provided this is borne in mind, this volume is undoubtedly notable, well-documented and a valuable compilation of the facts about the development of DDT for large-scale usage, its successes, its failures, and the early impacts of insecticide resistance on the new outlook which DDT had first made possible in medical and veterinary entomology. There is no index; this may be intended at the end of the series. An introductory table of chapter content, further sub-titling and some cross-references in the text, and the good quality of printing and illustration combine to make this a pleasing book to handle and consult. D. S. Bertram

INCENDIARIES, FIREWORKS AND FIREARMS

A History of Greek Fire and Gunpowder

By Prof. J. R. Partington. Pp. xvi+381. (Cambridge: W. Heffer and Sons, Ltd., 1960.) 70*s*. net.

In his new book Prof. Partington surveys the history of incendiaries and gunpowder in the same thorough way that characterized his well-known "Origins and Development of Applied Chemistry". He has taken great care to inspect the original sources of information, and he quotes them at length in the seven fully annotated chapters of this book, which has been completed by good indexes and twenty-one illustrations, some of which are seldom reproduced.

The book opens with a discussion of the incendiaries used in ancient warfare, culminating in the 'Greek fire' which terrified the Crusaders and which was one of the props of the Byzantine Empire. Many of these ancient incendiaries contained one of the numerous types of crude oil found in Mesopotamia or the regions north of that country. The author believes that the basis of the earliest Greek fire was liquid rectified petroleum or volatile petrol, which was projected in hand-grenades, or ordinary petroleum in tubs shot from *ballistae*. The mixture of petrol and resinous substances, thickened into a jelly, and the mechanical means of projecting it constituted the invention of Greek fire, an achievement of chemical engineering.

In his second chapter the author turns to the examination of "The Book of Fires of Mark the Greek", which he compares with passages from Albertus Magnus's "De Mirabilibus Mundi" and Roger Bacon's "De secretis operibus artis", from which he concludes that there seems to be no reasonable doubt that Roger Bacon was well acquainted with the preparation and properties of gunpowder, though probably ignorant of its use as a propellent. He may have derived his knowledge about its composition from the "Liber Ignium", which is probably of Arabic origin.

The next chapter is devoted to the "Legend of Black Berthold", the imaginary German monk said to have invented gunpowder and cannon. The earliest picture of a cannon is found in an English document, its earliest mention in an Italian one of 1326. He then proceeds to discuss the earliest English, French, Burgundian, German and Italian cannon and their nomenclature. A further chapter discusses miscellaneous fifteenth-century treatises on military arts and their knowledge of the use of gunpowder and firearms, mines and rockets.

Chapters 5 and 6 are devoted to a systematic discussion of gunpowder and firearms in Muslim lands and in China. Here the author dispels many erroneous statements of earlier authors by carefully examining the original texts and consulting such experts as Holmyard and Needham. His conclusions are that saltpetre was known under the Sung dynasty (A.D. 960–1279), and that around 1044 certain 'proto-gunpowder' mixtures were used in bombs but not as propellents. About 1233 we find the prototype of a gun described in Chinese literature, and true gunpowder was known towards the end of the Mongol Yuan dynasty (A.D. 1260–1368), when it was also known in Europe. Though there is a possibility that gunpowder was discovered in China, we are not certain that cannon were invented in that country, as the information about cast-iron Chinese guns, said to date back to 1356, is unsatisfactory. The Arabs seem to have introduced gunpowder from the East, first using it as an incendiary like Greek fire. Cannon and firearms seem to play a part from the fifteenth century onwards only in Ottoman warfare.

The last chapter is devoted to the history of saltpetre. Here the author could have consulted with profit M. Levey's essays on chemical technology in ancient Mesopotamia rather than the much older evidence he quotes; although his discussion of the classical and post-classical evidence of this most important ingredient of gunpowder is excellent and provides us with many useful data on the ancient manufacture of saltpetre.

Prof. Partington has again given us a handbook which not only the artillery expert and the chemist but also the historian of technology will consult with profit for many years to come. R. J. Forbes

Birds in Colour

Illustrated by Karl Aage Tinggaard. With descriptions by Bruce Campbell. Pp. 103+256 plates. (Harmondsworth, Mddx.: Penguin Books, Ltd., 1960.) 21*s*.

IT must be exceedingly difficult to produce yet another moderately priced book on birds that has its own merits and justifies itself as a purchase both for beginners and experts. The compiler of "Birds in Colour" has managed to do this by producing an outstandingly straightforward reference book that makes bird recognition comparatively easy for "those who go about in the towns, in the country and by the sea in the British Isles—and those who look observantly out of their kitchen windows"; at the same time producing a very beautiful book of pocket-size.

The book has two main sections. First, there are 256 coloured paintings of all the birds likely to be seen and recognized in the British Isles, arranged, roughly, in the Hartert order. Each bird takes up half a page, and similar birds, likely to be confused, are on adjoining pages. This makes it possible for four similar birds to be compared at a glance. The second part of the book is devoted to the descriptions, which bear the same number as the paintings earlier in the book, thus enabling speedy reference. This section gives such information as habitat, appearance, voice, habits; and a very helpful note on the other birds with which this one is likely to be confused. This is particularly helpful for a beginner. At the end of the book is a short section of flight sketches, followed by a list of books to read, an index of Latin names, and, lastly, an index of English names.

The book is of the standard 'Penguin' size, but has a stiff, colourful cover, and each of the 256 paintings are not only realistic but also pleasing to the eye. The simplicity of the book is its main asset, as, while giving the maximum help in bird recognition, it avoids all technical terms and irrelevant data. All essential points are lucidly written—fitting companion notes for the Danish artist's paintings, which cannot be too highly praised.

B. J. G. MAITLAND

Flat Rolled Products

Rolling and Treatment. Edited by T. E. Dancy and E. L. Robinson. (Metallurgical Society Conference, Vol. 1.) Pp. xix+128. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1959.) 30*s*.

THIS book, the first of a series on various branches of metallurgy, is a report of the proceedings of a conference arranged by the Mechanical Working Committee of the American Institute of Mining, Metallurgical and Petroleum Engineers, all the contributors being connected with steel firms in the United States or in Canada. To this extent, the title may be somewhat misleading, since non-ferrous practice is touched on only by implication.

Six papers are included of which half the book is devoted to two on the factors affecting strip profile in hot- and cold-strip mills and on the closely related influence of hot-strip profile on subsequent operations. The remaining contributions are concerned with heat-treatment practice, the continuous normalizing of flat-rolled products, the continuous annealing of deep-drawing sheet and the theory and evolution of coil-heating practice in steel mills.

To the reviewer the most interesting part of these proceedings is a two-page paper dealing with the annealing of strip in liquid sodium. Considerable laboratory work has been done during the past few years with results sufficiently encouraging to justify pilot-scale operation. The main advantages envisaged include increased rapidity of heating and cooling, a reduction in the space required and lower maintenance costs due to simplification of the plant.

F. C. THOMPSON

The Nuclear Handbook

Consulting Editor: Prof. O. R. Frisch. Pp. xv+640. (London: George Newnes, Ltd., 1958.) 50*s*. net.

THIS book is described in the foreword as having been designed as a day-to-day reference for use by scientists and technicians working in nuclear science and related fields. There are nineteen sections of varying length written, generally, by specialists. The topics include, among others, the nuclear properties of isotopes and natural radioelements, and of fission product and transuranic elements; the theory of nuclear reactors and the properties of fuels and other materials used in them; and related technologies such as particle accelerators, vacuum techniques, and electronics.

The technical level and the style of the contributions vary a good deal. The first section, for example, contains an elementary description of the structure of the atom whereas the mathematical discussion of nuclear reactions in section 19 makes few concessions to the unsophisticated. This last section consists of a collection of equations and formulæ, with tables and graphs, connected by the minimum of narrative; the section on natural radioactivity is prefaced by two pages of history beginning with Becquerel.

The "Handbook" was published shortly before the second Geneva Conference on atomic energy, so that some of the data were outdated within a short time of publication. Nevertheless the book is a compact source for a wide range of information and should be useful, provided that reference is made to the periodical literature to check data in fields known to be changing rapidly.

K. E. B. JAY

Guide to Reference Material

Edited by Dr. A. J. Walford, with the assistance of L. M. Payne. Pp. viii+543. (London: Library Association, 1959.) 80*s*.; 12 dollars. (Members of the Library Association, 60*s*.; 9 dollars.)

THIS volume provides an annotated list, classified on the 1957 abridgement of the Universal Decimal Classification, of leading reference books and bibliographies, with emphasis on current publications and particularly material published in Britain. Maps, anthologies and most source books have been omitted, as well as the vast majority of periodicals, but in certain scientific and technical subjects, textbooks have been included, for want of more comprehensive works. It is intended for librarians, in the building up and revision of reference library stock; for use in general and special library work; and for students taking the Library Association examinations. Its 3,000 selected entries are the result of the work of some 70 contributors, and an admirably produced volume is well designed to serve as a point of departure for a much-needed series of detailed annotated guides on specific subjects, as is the hope of the editor, Dr. A. J. Walford.

R. BRIGHTMAN

THE ROYAL SOCIETY*

By Sir CYRIL HINSHELWOOD, P.R.S.

IN the year 1660 the Royal Society was founded. On the scale of cosmic evolution three centuries are as nothing, but by the measure of human life they constitute an impressive span of history. Time in Newton's philosophy flowed uniformly on, but as the matrix of events significant to men it is not measured by the clock. For thousands of millions of years the present galactic cycle has continued, for a few thousand civilization has been spreading round the Earth, and for a few hundred only there has been in progress that rapidly accelerating conquest of knowledge and power over Nature which has so largely created the world of to-day. The foundation of the Royal Society was symbolic of the conscious undertaking of this endeavour. In achievement the three hundred years have exceeded all the infinite wastes of evolutionary time: by the scale of human events they are the fullest and longest in all existence. For ourselves, in whom the dramatist can arouse emotion by recreating the events even of our own brief lifetimes, they have, in virtue of their scope, an almost epic grandeur. Yet they are short enough to move us in another way. The men who lived in Charles II's reign are still familiar to us as human beings. We can picture in imagination the King himself, and the echoes of his witty sallies have not yet grown faint.

For all the rapid change that continuously dissolves and recreates the scene of human activity the men who originated the Royal Society and who are in a sense the fathers of the present age are no further removed from us than our nearer ancestors. Their portraits look down on us, their words remain for us to read, we can feel we know them and have towards them something of a filial piety. We honour them and pay just tribute to them, and our admiration is infused with friendliness and warmth.

What manner of men were they whom we commemorate?

At the historic meeting on November 28, 1660, when the idea for the foundation of the Society was propounded, the record states that there were present "Lord Brouncker, Mr. Boyle, Mr. Bruce, Sir Robert Moray, Sir Paul Neile, Dr. Wilkins, Dr. Goddard, Dr. Petty, Mr. Ball, Mr. Rooke, Mr. Wren, and Mr. Hill".

In his diary Evelyn attributes to Brouncker, Boyle and Moray the credit, if not for the first initiative, at any rate for the furtherance of the project and for the surmounting of the initial difficulties and disappointments. Brouncker, an Irish peer, had at one time served Prince Charles. He had studied mathematics at Oxford and was later a doctor of medicine of that University. He was said to be a good linguist and he made some mathematical discoveries of importance, including that of continued fractions. He and John Evelyn, it is related, often discussed scientific questions with the King. He became the first president of the Royal Society.

Robert Boyle, the famous author of "The Sceptical Chymist", learned in many tongues, devoted the leisure of a great gentleman to a life of study and was renowned not only for his learning but also for his piety, his religious and moral writings being probably as numerous as his scientific works.

A very different figure was Sir Robert Moray, who combined the qualities of a scholar with those of a man of action. He had served as a soldier under Louis XIII and had been with King Charles in France. After the Restoration he held public offices, enjoyed the confidence of the King and was described by Huygens as the soul of the Royal Society, to which at various times he made communications on geology, natural history and comets. He has been spoken of as a chemist and a mathematician and, according to Pepys, was interested in music.

A man who in the opinion of some deserves to be thought of as the real originator of the Society was John Wilkins, warden of Wadham College, Oxford, and later Bishop of Chester, wise, tolerant, conciliatory, continuing his work both under Protector and King. He was the central figure around whom gathered the group of learned men which later turned itself into the Society. He had a forward-looking mind, and not only wrote a work on the Moon as a habitable world but composed also a discourse on the possibility of a passage there by 'volitation'.

There are philosophers of history who would maintain that the Royal Society had to come into being when it did, irrespective of individuals, because the climate and temper of the age demanded it. They may be right. It must needs be, perhaps, that such things come, but all honour, nevertheless, to the men by whom the necessity is fulfilled. If the individual does not determine the event he profoundly influences the manner of it.

These men, in whom the elements were thus diversely mixed, initiated the humane tradition of the Society, the union of thought and action, the partnership between men of the study and men of the world, which has been maintained throughout its existence, is preserved, we would like to hope, to-day, and will decide its future.

In illustration of a preconceived thesis, the reception of the new Society could be represented in diametrically contrasted manners. Names like Christopher Wren, John Evelyn, Samuel Pepys and John Dryden bear witness to the width of its appeal. Could we indeed quote anything like so varied a list at the present time? The sympathy of the literary world was not lacking. Addison styled Robert Boyle "an honour to his country", persons of consequence consigned their sons to the care of Warden Wilkins, and the patronage accorded to the Royal Society by established authority was neither purely formal nor mere lip service. Prince Rupert made communications on his own account. The Earl of Sandwich, sent to escort Catharine of Braganza from Portugal, allowed himself to be set the task of making observations for the Royal Society on the tides and on the saltness of the sea. The King himself was on terms of friendly intimacy with many of the members, often visiting with Sir Robert Moray the laboratory established in Whitehall.

* Address delivered at the Formal Opening in the Albert Hall, London, of the Tercentenary Celebrations on July 19.

If the illumination is suitably adjusted, however, a less-mellow picture emerges. The Warden of Wadham might be a leader of the new movement: Dr. Fell, the formidable dean of Christ Church, would have none of it. The Public Orator of the University of Oxford declaimed against the Royal Society in the Theatre built by Wren, and Antony Wood declared it to be an obnoxious body. Bishop Wilkins, Bishop Ward and Bishop Sprat might defend the new philosophy with every strength of argument and eloquence, Robert Boyle might write the "Christian Virtuoso", every protestation and example of piety and orthodoxy might be offered by the Fellows, none of this prevented attacks from the pulpit, and the strangest accusations from other quarters.

The complaints openly made by the objectors were of atheism, impiety and subversion, or if not the practice or countenancing of these things then at least the creation of a philosophy which would lead the weaker brethren into evil thoughts or be used by the wicked as a cloak and excuse for their depravities. Besides operating on the side of the godless and corrupting the innocent, the Royal Society was at the same time supposed (though scarcely, it may be presumed, by Catholics) to lend itself to popish schemes. It elevated sensual ideals, and it encouraged great expense of spirit in the pursuit of vain truths. It might challenge the authority of the universities and invade the province of the physicians.

Much of this was still reverberating yesterday and even lasts to-day, and in this respect the three centuries assume perhaps their shortest perspective. In our own time scientific studies have received extravagant praise and intemperate criticism. One great novelist of this century saw the millenium about to be realized through science. Lesser literary figures of the moment have laid every defect or misfortune, from intellectual arrogance to social obscurity, at its door.

Every complaint and reproach levelled in the seventeenth century, every fear expressed, every resentment, interested or disinterested, openly or secretly working, can be paralleled in the recent past. Every anxiety, misgiving, criticism or reserve voiced to-day has been countered by the seventeenth-century apologists. Nor can the threat of destruction by the release of nuclear energy really have aggravated the issue, for the perils of atomic warfare are at least no more terrible than the prospects of eternal damnation to which many in the earlier age believed the new doctrines were leading men.

If criticism could have restrained or gibes deterred, if any combination of polemic and persuasion could have mollified or silenced, the issue would have been settled once for all. But these strange contests of seemingly incompatible philosophies have periodically renewed themselves, rising to great climaxes like the controversy over evolution in the nineteenth century and the quarrels about the use of nuclear energy in the twentieth century. The origin lies more in emotion than in reason: genuine fear of the unknown, reverence for established things, but most of all in the strangely partisan instincts of men, the manifestation of their combative and yet gregarious nature. What happened after the foundation of the Royal Society was largely a reflexion of a permanent or at least a strongly persistent pattern.

But the most significant circumstance is that the attitude of the world at large probably did not seriously determine the course of science. In the seventeenth century the contest was largely a battle of the books. The opponents of the Royal Society did little effectively to hinder it. Nor indeed, after the first flush of enthusiasm, did the majority of its non-scientific or fashionable supporters do very much actively to help it. The record of sermons, pamphlets and other forms of the written word is the raw material of a one-sided story. The literary basis of so much history can easily falsify the perspective. Writers express their views and other writers, by the natural working of affinity, often attach undue importance to the evidence that these afford. A few dramatists can characterize a whole period as licentious, even resolutions of undergraduate debating societies if they catch the fancy of the journalists may help to fix a label on an age. But the future germinates unknown and silently.

From the time of the foundation of the Royal Society onwards there was a steady increase in the number of dedicated men who, by the concentration of their minds, the skill of their hands and the sweat of their brow, worked to uncover the secrets of Nature. Their labours were largely unknown to their contemporaries; they are but perfunctorily recorded by historians, and yet they have ended by transforming the face of the globe and the life of humanity. The literary battles of the detractors, the satirists and the apologists had little effect. The men of science lived up to the motto proposed for the Royal Society by Evelyn *Nullius in Verba*, accepted the authority of none, and were on the whole unmoved by praise or blame.

The nature of things is such that two of the early criticisms of science have refuted one another. It was, some said, too much concerned with material ends: it indulged, according to others, idle curiosity to the good of nobody. The answer to-day is clear. The technology which has transformed practical existence is largely an application of what was discovered by these allegedly irresponsible philosophers. On the other hand, their shortsighted and earthy preoccupations have entrained an upheaval of the whole of human thought. By what strange workings of destiny does this come about? The propounding of ambitious practical aims seldom leads to their fulfilment. "Find me a way" an ancient despot might have said, "to send invisible messages round the world, and I will ennoble and enrich you". The reward would never have been won. "Find out", he might less plausibly have said, "about the strange force in this little piece of amber". This apparent frivolity contained the secret of his first requirement, but remote and unforeseeable.

The full fruition of scientific work depends upon three things: the desire to know, the initiative to find out and the awareness to apply. Highly special conditions have to be fulfilled before the plant will bloom, before the flower will fruit and before the fruit will ripen.

Let us have no illusions about one thing. To-day we commemorate the doings of a minority and of a small minority. The King himself was a rare figure among the rulers in history. The glamour shed on the Royal Society by his patronage ensured the respect of the eminent but not their subscriptions, and in the year 1700 the corporate income did not exceed about £100.

But if the men of science did not continue to receive much material support they were not for that reason without significance to their time. Who is representative of an age? The acclaim of the day seldom anticipates the verdict of posterity, since the germinal things are almost always hidden or unrecog-

nized. Most conventional history records the waxing and waning of political movements, the course of wars and the fate of dynastic ambitions. These have been deemed the proper material for polite studies. The adventure and achievements of science have seldom been vouchsafed the attention of the chronicler, nor has their study usually been rated as humane. Yet they have not only transformed the conditions of life but they are the product of human genius, and above all of the determination, sacrifice and devotion of men who must on that account be deemed among the foremost representatives of their day.

What then have the men of science done in these three centuries? How have they changed the course of history? These questions raise further ones. Is the change to accelerate further or come to a halt? What does it mean to us? It has brought us face to face with great dilemmas. Can the pursuit of knowledge any longer remain the concern of the few? What then shall we do?

After Newton's great synthesis, the law of universal gravitation, the conception of the stellar universe as an ordered mechanism, made probable by Copernicus, Galileo and Kepler, could no longer be in doubt, and grew in strength with the continuous elaboration of Laplace and his successors. Newtonian mechanics, wedded to the inventiveness of practical men, created modern engineering, and thereby made man largely the master of his environment, bringing him at length to the threshold of extra-terrestrial space. Twentieth-century ideas, largely under the influence of Einstein, imparted a more abstract character to the fundamental notions of space and time, matter and energy; and by a strange paradox of Nature it has been one of the most recondite and immaterial of adventures that has led directly to the release of nuclear energy and confronted mankind with one of the greatest practical problems it has ever faced.

The obscure and apparently unrelated curiosities of electricity and magnetism were unified at long last into the great body of electromagnetic doctrine. They provided the basis of electrical engineering and electronics by steps too intricate to trace in detail, but of which a crucial one surely was guided by the simple faith of Faraday that these two great natural forces were related. The patient genius with which he pursued his intuition was in its way prophetic, but he had little premonition of electric railways, of television or of automation.

The not infrequently disreputable operations of the alchemists grew into the science of chemistry. The atomic theory, fruitful after two thousand years, when experiment had replaced speculation, revealed at last the true secret of Nature's elements and compounds, and guided the creation by man of compounds Nature never knew. The stages in the development were complicated, the interrelations and inter-dependences of ideas and discoveries have been intricate beyond the possibility of any brief description. Contributions might come from any quarter. It would probably be agreed, for example, that among the many through whom the wonderful modern plastics industry traces its descent there stand out an Irish gentleman, a French State official, a Manchester schoolmaster, a German professor and an American industrial research chemist. Truly inspiration bloweth where it listeth, and no man can tell whence it cometh and whither it goeth.

The forms of plants and animals, the structure and function of their parts, have slowly unveiled their mysteries, and biology has joined with chemistry to create the modern art of medicine. All the sciences have now converged on the study of life, from the simple cell to that most wonderful of instruments—the human brain.

In the last hundred years the pattern of daily life has been transformed. Things which in the reign of Charles II would have seemed like the dreams of visionaries or indeed the impostures of charlatans are now part of the common scene. Flight, speech and vision across the world, cures as by miracle from deadly illnesses, machines to which men delegate heavy toil, dextrous manipulation or mental exertion far beyond their own unaided powers, colours surpassing the rainbow in variety, all these things and more have come into being. The keys to unlock atomic energy have placed in man's hands undreamed of powers which he may use for good or evil. The keys which unlock some of the secrets of human personality are slowly being cut, and men may soon be using them to do we know not what.

Is this not history?

In the realm of ideas the story has been even stranger and more turbulent. The conception of the universe as a mechanism suggested a materialistic view of all existence, though not to Newton himself, and possibly less often to men of science than to onlookers unconscious of the real intention of scientific hypotheses. The time-scales revealed by geology and biology appalled those who confused the literal truth of "Genesis" with the basis of religion and morality. And when the theory of evolution completed the outrage of man's expulsion from the centre of the universe by denying his special creation, resistance rose to its height. The opposition subsided only to be renewed at intervals against scientific doctrines, all of which have been of unquestioned utility in their own spheres, about the unconscious mind, about the chemical basis of genetics, the functioning of the brain and nervous system, or about the influence of hormones on personality.

Yet the men of science themselves, so far as can be judged, have numbered about the same proportion of religious believers as the generality of people. Nor have they been conspicuously less well endowed with kindness or morality. Indeed, an assurance that ultimate values of goodness and beauty can never be shaken by the pursuit of truth, wherever it may lead, is perhaps the sign of a robuster faith than is shown by recoil from every new and seemingly disturbing fact.

Meanwhile, in the natural course of discovery and interpretation, and uninfluenced either way by real or supposed philosophical or theological implications, scientific ideas evolved in a direction where they largely lost again their mechanical and materialistic semblance, and acquired a curiously abstract character. Indeed, some physical principles (though not, I think, adequately understood), have even been used in the present century in support of idealistic philosophies or to provide a doubtful support for the otherwise respectable doctrine of free will.

The quantum theory added a new element, that of discontinuity to the Newtonian conception of the world. Electrical particles, the building blocks of matter, filling the universe with electromagnetic waves by their motions had offered for a time a synthesis of grand simplicity, powerful enough to create the whole technology of radio communications, and a major part of the electrical industry, yet itself destined for a revolutionary metamorphosis. Nature gradually disclosed that the invisible substratum of

things, electrons, particles and waves could no longer be described at all in terms applicable to the macroscopic world of the senses. Intuitive notions of space and time had been called in question by the theory of relativity; the idea of a sub-atomic particle now became expressible only in terms of an abstract mathematical equation. Electrons themselves proved subject to the peculiar rule that only so many of them could be present in one system as were absolutely distinguishable by individual values of certain numbers which prescribe their state. Separate existence and experimental distinguishability were essentially linked. It is this almost metaphysical principle which accounts for the complete system of the chemical elements, with all their rich and varied detail. Particles appearing in nuclear disintegrations at high energies, mesons and the like, possessing the character of transience and decaying into others, present to-day an enigma which will probably not be solved until radically new principles have been discovered. The mysteries of the minute world of the atomic nucleus are found in magnified reflexion in those of the stellar universe. How did the present cosmic era start? Will it be renewed? Is the so-called ultimate particle itself a cosmos of still smaller things? Is the known universe contained within a particle belonging to some higher order? Mystery and fascination have no end, the pursuit of knowledge has no limit. Three hundred years have witnessed the most colourful adventure ever undertaken. Is this too not history?

In the broader sense this story is that of the Royal Society, for its membership has known no restriction of race or nation. It has been proud to number a goodly proportion of the world's greatest men of science among its Foreign Members.

The real actors in the drama of these centuries have been individuals, often rare individuals. What then in it all has really been the role of the Royal Society as a corporate body? This question is related to that most profound of problems, the relation of the individual to the community.

The hierarchical ordering of things, which can be seen both in the inorganic world and in the organic world, makes the community of one order the individual of the next order, not only through the gradations of human society and the animal kingdom, but also in the relation of cells to tissues, electrons to atoms and atoms to crystals. An almost metaphysical principle rules communities of electrons, chemical influences co-ordinate the lives of separate cells, and, to quote a single instance from biology, some mysterious kind of transmission beautifully regulates the flight of certain flocks of birds.

The modes of communication in human societies are known; but what remains mysterious is the blend of rational and emotional influences that determines the response. The great movements of thought and even the lesser ones of whim and fashion spread from leaders. Only minorities in general exercise an independent taste and judgment or produce original thought. Yet at one time a prophet is followed and at another he cries in the wilderness. Avogadro and Mendel achieved their fame posthumously. Literary reputations wax and wane. The shrewdest are unable to predict with certainty what public response to anything will be. The propagation of an idea demands the right conjunction of unknown human factors, but even when these are propitious nothing will initiate the change save the operation of a minority small enough to defy statistical considerations. Often indeed the minority begin with a single individual who alone would be helpless; and thus the majority and the minority are held in mutual dependence.

Scientific investigation needs material ways and means, and the further knowledge advances the more lavish becomes the scale. The individual in isolation becomes, except under rare conditions, correspondingly impotent. But the community as a social and political whole cannot be expected to possess the detailed understanding to support him. Nor, to-day, with the tremendous issues at stake, can it remain indifferent. What therefore must be created to mediate between the individual and the major group is a specialized minor community large enough to command prestige and confidence, but with membership confined to those who place the claims of knowledge first. The principles which should govern the constitution of such a body are highly important.

Specialized organs of the Government are by themselves unsafe, being too exposed to the changing winds of expediency. Universities suffer from the disadvantage that on one hand a given branch of knowledge is divided and scattered among many of them and, on the other hand, that they have competing preoccupations of importance to them commensurate with that of learning.

An academy therefore is the natural body to provide for several vital things—non-commercial periodicals for the publication of discoveries, a measure of financial support for ideas still too embryonic to be of immediately obvious practical application, the mutual stimulus of association and discussion and the immaterial reward of honour for intellectual achievement. Governments may act as patrons. They can and do solicit and receive the help of learned men, they favour and encourage enterprises which they judge to be timely; but they cannot provide for men of science the intangible yet powerful encouragement which comes from acceptance and election by their peers. The academy, if it maintains high standards of unquestioned impartiality, sets the tone throughout the scientific community, and its influence is felt in every quarter. It is no rival to government organizations or to industry, and should maintain the closest connexions with them by electing into its number the leaders from both. Because men of action and men of authority esteem it an honour to be elected, the academy exerts its influence far beyond the confines of the learned world. The professional men of science hear of the needs of the State and of industry which in their turn are irrigated by the currents of scientific thought. The intercourse on terms of equality between the representatives of these different estates of the nation is like a sensitive nervous mechanism endowing the community which possess it with capacities and potentialities realizable in no other way. The subtle co-ordinating action of an academy can no more be replaced by a bureaucratic organization or a system of economic incentives and deterrents than the intricately evolved biological controls of a living organism can be replaced by crudely devised mechanical appliances.

As Nature herself takes infinite pains over the perpetuation of the species, making this indeed in most respects her first concern, so the right choice of its members is a matter demanding the most anxious care of the academy, and is perhaps the most important thing it has to do.

This, then, is the conception of the Royal Society, implicit already in the personalities of its original

members and in their relation to its royal Founder, and moulded by the humane tradition of 300 years, that it should mediate between the individual and the community, depending on the loyalty of the one and on the sympathetic understanding of the other. The record of what the natural sciences have contributed to life and thought should justify the claim that this humane tradition has borne good fruit.

Science has never been restricted by the confines of nations, and we proudly claim the Foreign Members of the Royal Society as leading actors in its story. Nor is it too much to maintain that the flow of ideas and of goodwill through scientific channels has contributed, and can contribute, sometimes in adverse circumstances, towards the peace and harmony of all mankind.

On this day of commemoration, when the Royal Society lays the account of its stewardship before the world, it is meet to look not only backwards but also forwards. What is to be the future of science?

Extrapolation of history is impossible, perhaps in principle, certainly in practice. The equations of the present allow three possible types of solution for the future. Decline and catastrophe have been predicted on one ground or another, in spite of science, by overpopulation and starvation, or, through the agency of science, by wholesale destruction in nuclear warfare. Continued and accelerated progress have been confidently foretold, the curve sweeping upward faster and faster as each advance in knowledge multiplies the possibilities of further discovery, and as man more consciously assumes control of his own further evolution. Between lies the third and less-spectacular solution, that the curve will level out or gently undulate. But the equations are insoluble, at least by any means we know. The uncertainty afflicts and inhibits some people; but their timidity is scarcely justified or useful. There has seldom, if ever, in the world's history been a time when existence was not in some degree precarious, yet the right response to danger lies in action. Faith in the future has indeed a very great survival value. The better equipped are certainly more likely to survive than the worse equipped, and not only to save themselves but also to save others.

The task of the men of science is therefore clear. It is to go ahead undeterred by any of the uncertainties. Faith in science is not incompatible with or exclusive of any other kind of faith. Indeed, there would seem to be no inconsistency in believing that scientific knowledge is itself one of the great instruments of higher ends. However that may be, duty, expediency and the zest of living unite their voices in calling for unremitting effort, not in the certainty but in the hope and faith that knowledge may advance, mastery over environment increase, drudgery be abolished, sickness healed, the people fed and life made happier. If social and moral problems are raised they are not essentially new but part of an age-old drama, and should neither be allowed to cause despondency nor to justify obstruction or abstention. The ancient choice between good and evil is in principle unchanged by the scale or fullness of existence. Men have always had to struggle with their environment, with one another and with themselves. Not exemption from danger, hostility or temptation but the power to sustain their impact has made men what they are. The great weapons have been the things of the mind, and among the greatest of these is knowledge. While the old men dream dreams and the young men see visions we should go forward undeterred, that the dreams may become reality and the visions be fulfilled.

This commemoration is for us a great event in our history. The future is unknown. The chronicles record the actions and the thoughts of men, and if, as well may be believed, thought is a creative process, then the future is more than deeply hidden: it is uncreated. The golden promises offered by the release of nuclear energy, by the exploration of outer space, by the discoveries of genetic mechanisms may in one way or another be redeemed, but the best are yet unspoken. A great upheaval of ideas may come with a complete re-orientation of science in its relation to philosophy and to the conception of possible worlds. But we know neither the day nor the hour.

It is the duty of the Royal Society not to predict, not to legislate, but to maintain within the larger community the smaller one in which creative activity can flourish. Its members owe a multiplicity of loyalties, none of which can be fulfilled without the others: to mankind in general, to their native land and to the Royal Society itself. But that is not all, for there are communities in time as well as space. The most original minds, in some sense isolated in all contemporary groupings, find their true affinities in continuing the sequence of their predecessors, and their fulfilment only in their successors. In a measure this is true not only of genius but of all men. It is what moves us in history. It is what the honouring of this occasion means.

TRIASSIC SALT: DISCOVERIES IN THE CHESHIRE–SHROPSHIRE BASIN

By Sir WILLIAM PUGH, O.B.E., F.R.S.
Director, Geological Survey of Great Britain and Museum of Practical Geology

THE 6-in. to the mile survey of the Cheshire Basin and its extension into north Shropshire undertaken by the Geological Survey of Great Britain as part of its programme of work authorized by the Department of Scientific and Industrial Research is approaching completion. The Triassic rocks are locally concealed by thick superficial deposits of Pleistocene sands and clays; detailed stratigraphical knowledge was lacking of the Keuper rocks and, in particular, of the number and extent of the rock-salt beds within them. To facilitate the interpretation of the disposition of these rocks below the Pleistocene cover and to assist in the mapping of them, a scheme of shallow exploratory boreholes was utilized.' A series of twenty-five boreholes, 300–1,000 ft. deep, were drilled within an area of 800

square miles in the Cheshire Basin; and one deep borehole has just been completed at a depth of 5,531 ft.

This deep borehole was undertaken to prove the succession of Keuper rocks beneath the Liassic strata exposed in the Prees outlier, which extends south-westwards from south Cheshire into Shropshire. Sited at Wilkesley (Cheshire) about five miles east of Whitchurch (Shropshire), the borehole revealed a thickness of 4,969 ft. of Keuper rocks, and a concentration of rock salt in two groups (each with subordinate marl partings) which together total 1,952 ft. in thickness. An abridged log of the borehole is set out below, using names for the newly established divisions of the Keuper:

	Thickness (ft.)	Depth (ft.)
PLEISTOCENE: sands and clays	58	58
LIASSIC: clay with limestone bands: both sub-zones of the *Psiloceras planorbis* zone are provisionally identified	460	518
RHAETIC: mudstone and black shale	44	562
TRIASSIC: Keuper		
Upper Keuper Marl: marl, 'tea-green' in top 50 ft.; gypsum at 950–70 ft.	579	1,141
Upper Keuper Saliferous Beds: rock salt with subordinate beds of marl	1,327	2,468
Middle Keuper Marl: marl with subordinate gypsum and anhydrite	1,073	3,541
Lower Keuper Saliferous Beds: rock salt with subordinate beds of marl	625	4,166
Lower Keuper Marl: marl with subordinate anhydrite	843	5,009
Sandstone, provisionally called *Upper Keuper Sandstone*	346	5,355
Siltstone, mudstone and silty sandstone, provisionally identified as *Keuper Waterstones*	176	5,531

The borehole failed to reach the base of the Keuper Beds; Permo-Triassic rocks older than the lowest bed reached are about 3,000 ft. thick in other parts of the Cheshire Basin, but not necessarily at Wilkesley.

The finding of two groups of saliferous beds in this borehole, rather than one as previously believed, has important consequences when the lateral extent of each group is delineated. The old-established salt industry of Northwich and Winsford is now known to be based on the lower group; on the other hand, the industry farther south at Sandbach and Middlewich appears to take its salt from the upper group, the lower group not yet having been exploited in that southern region.

The area occupied by the lower group from its western and northern margins to the eastern boundary fault of the Cheshire Basin is about 400 square miles and that of the upper group is about 170 square miles. The reserves of salt which could reasonably have been computed before the drilling of the Wilkesley Borehole have been at least doubled; a provisional estimate amounts to 400,000 million tons, of which more than 60 per cent is in the lower group.

The outcrops of the main divisions tabulated above will be shown on the forthcoming official geological maps of the Cheshire–Shropshire Basin. Their recognition will enable a new degree of precision to be brought to the long-term planning and execution of brine-pumping. The salt encountered in the boreholes was cored and is being systematically analysed so that details may be made available for industry.

It is interesting to record that one of the shallow boreholes near the western margin of the basin, namely, that at Old Beachin Farm, six miles south-south-east of Chester, entered barren Upper Coal Measures beneath the Pleistocene deposits enabling the mapping of an inlier of Coal Measures surrounded by Permo-Triassic rocks. The borehole was deepened to 993 ft. and a sequence comparable with the Erbistock Beds of the Wrexham Coalfield was encountered. However, workable coals, if present beneath the central parts of the Cheshire–Shropshire Basin, are likely to be at depths too great for present-day exploitation.

PERIODIC MAGNETIC FIELD FLUCTUATIONS IN THE *SCEPTRE* DISCHARGE

By DR. N. L. ALLEN

Research Laboratory, Associated Electrical Industries, Aldermaston Court, Aldermaston, Berkshire

ALTHOUGH the discharges in *Zeta*, *Sceptre III* and *Perhapsatron* appear to be stable against gross wriggling[1–3], measurements with magnetic probes have invariably shown fluctuations of magnitude about 10–20 per cent of the average magnetic fields in the discharge and mean frequencies in the range 10^4–10^5 c.p.s.[4]. Also, some correlation has been observed between striated bands of light, termed 'bars', on rotating-mirror photographs and the magnetic fluctuations[5,6].

A possible theoretical explanation of these fluctuations has been given by Ware[7]. This has recently been extended[1] by including the Hall e.m.f. in the electron conduction equation, and it has been suggested that a hydromagnetic instability will propagate as a wave. The experiments reported here form part of a search for discernible instabilities of this type.

Experimental Arrangement

The arrangement is shown in Fig. 1. Ten small search coils, each of 120 turns of No. 44 s.w.g. copper wire, were wound at intervals of 1·25 cm. on a 4-mm. diameter 'Bakelite' rod. The assembly was enclosed in a T-shaped tubular glass envelope, with the coil leads taken out through the side tube. It was then inserted into the torus through a slit window and rotated until the common axis of the coils was parallel to the toroidal axis (neglecting the curvature of the latter over the length of the coil assembly).

The coils were positioned at radii up to 10 cm. from the centre of the toroidal tube, which had a minor diameter of 30 cm.; thus they were 5 cm. from the outside wall of the vessel at the mid-point of the coil system. The output of each coil was led to an integrator and then displayed on a multi-channel oscilloscope. Hence, correlation in time between the response of the individual coils was obtained on a single photograph.

The plasma was produced by discharging a 35,000-joule condenser bank through the primary winding of the machine. The condensers were charged to 20 kV.

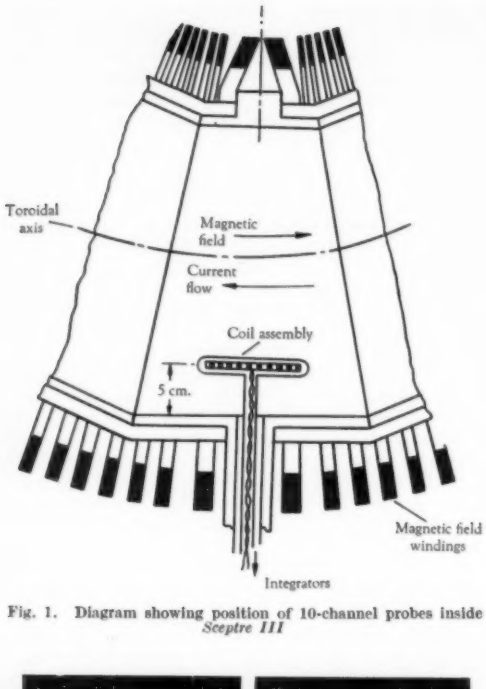

Fig. 1. Diagram showing position of 10-channel probes inside *Sceptre III*

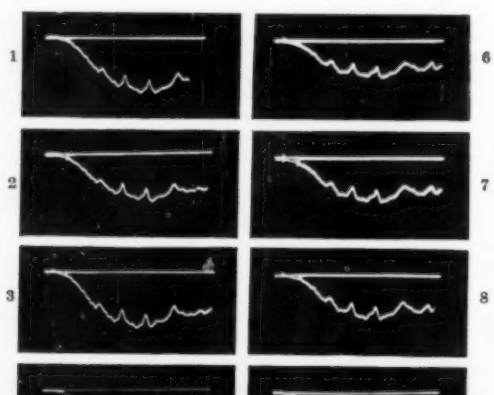

Fig. 2. Oscillograms of signal obtained from 10-channel probe system. Four minima appear and move along from No. 1 probe to No. 10 probe. (350 μsec. sweep)

With a step-down turns ratio of 16 : 1 this gave an initial secondary voltage per turn in the gas of 1,250 volts. The current pulse, which was nearly critically damped, was of 800 μsec. duration, rising to a peak of 140,000 amp., 240 μsec. from the start. An initial magnetic field of 1,000 gauss at the toroidal axis was applied. The initial deuterium pressure was $1 \cdot 4 \times 10^{-3}$ mm. mercury.

Fluctuation Behaviour

Typical oscillograms obtained with this arrangement are shown in Fig. 2. The pattern of periodic 'dips' or minima in magnetic field was obtained in a region between 6 and 10 cm. from the centre of the discharge tube along radii towards the outer wall. Further probe measurements showed the existence of similar patterns at corresponding radii near the other walls of the torus. The pattern was found to be repeated in these regions in 65 out of 86 discharges examined ; in the remaining 21 cases the pattern was less regular, or showed few recognizable 'humps'. The magnitude of the 'dips' varied from ~ 200 to ~ 1,000 gauss.

The time-intervals between pairs of minima varied between 25 μsec. and 100 μsec. with an average of ~ 45 μsec. for 113 cases examined. A histogram showing the frequency distribution of these intervals

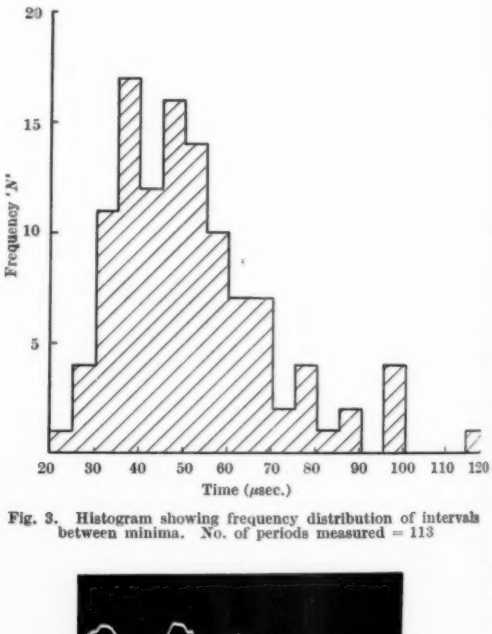

Fig. 3. Histogram showing frequency distribution of intervals between minima. No. of periods measured = 113

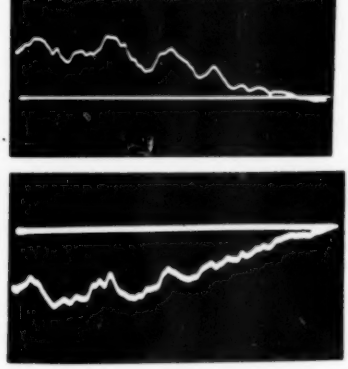

Fig. 4. Oscillograms of signals from probes placed on opposite sides of discharge. (350-μsec. sweep)
Upper, No. 4 probe, centre + 5 cm. ; lower, No. 8 probe, centre − 5 cm.

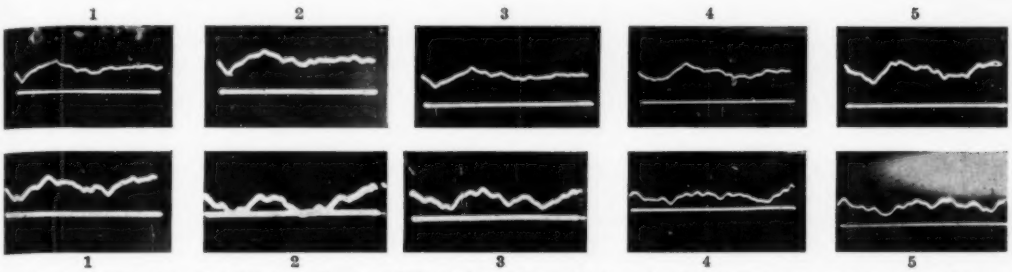

Fig. 5. Oscillograms of signals from T-probes along radii at right angles to each other. Upper row: probes 7·5 cm. from outside wall of torus; lower row: probes 7·5 cm. from upper wall of torus. Base line in each oscillogram 0–100 μsec.

is given in Fig. 3. Measurement with a travelling microscope showed an increasing time-lag between minima on No. 1 coil and those on succeeding coils up to No. 10. The average time-displacement between the end coils for 72 minima investigated in this way was 8 μsec. over the total length of 11 cm. covered by the coils, with intermediate time differences recorded by the intermediate coils.

Further investigation into the nature of the fluctuations was made by inserting a 10-channel probe across the discharge to measure axial field changes at 2·5-cm. intervals. Specimen oscillograms obtained are shown in Fig. 4, from which it is clear that an anti-phase correlation existed between peaks and dips occurring on opposite sides of the centre of the discharge.

Fig. 5 shows the relationship between the patterns obtained with T-shaped probes inserted along radii at right angles to one another in the same cross-sectional plane. The interval between peaks on the individual oscillograms (shown here on a fast sweep) was ~ 80 μsec. and the minima were displaced about 15–20 μsec. with respect to one another.

In Fig. 6, the average axial and azimuthal components of the discharge magnetic field relevant to the observations quoted above are shown. These are plotted, at peak discharge current, against tube diameter for the same initial conditions. The T-shaped probe covered the areas about A. They are on steeply rising parts of the B_φ component in which the resultant magnetic field 'wave-lengths' ($2\pi r\, B_\varphi/B_\theta$) vary between 26 and 175 cm.

Discussion

The time-displacement of minima along the probe assembly indicated either a velocity component of the pattern in the axial direction or a rotational motion in the azimuthal direction of a disturbance lying at some angle to the probe axis. The techniques used here could not distinguish between these two alternatives.

Taking the former possibility: a total of 72 minima was followed in their progress along the probe assembly and a spectrum of axial velocity component obtained as in the histogram of Fig. 7. The velocities showed a maximum in number at about $1·5 \times 10^5$ cm./sec. A group of 17 minima existed in which a velocity was not resolvable, since they showed no significant time displacement along the probe. These are shown here as having a velocity $>5 \times 10^6$ cm./sec. However, these minima could equally well correspond to a pattern of zero axial velocity component appearing simultaneously on all probes. The resolvable velocities (55 cases) were in the direction of positive ion drift in every case.

The alternative of azimuthal motion of an angled disturbance would indicate an angular frequency spectrum similar in profile to that of the distribution of Fig. 3, where the time axis is replaced by the reciprocal of the frequency. At a mean radius of 8 cm. from the centre, this corresponds to a mean peripheral velocity of the order $1·0 \times 10^6$ cm./sec., assuming only one perturbation for each rotation.

The results are consistent with a model of a helical disturbance moving, axially or azimuthally, in the discharge. This model is supported by the observations, with probes on either side of the discharge centre, of an antiphase correlation and by the observation of a phase shift between the two probes at right angles. The results suggest the presence of an $m = 1$ type of instability. Such behaviour has been reported by other experimenters[9,10] at lower discharge currents. The present results do not depend critically on discharge current values, since the fluctuations occur over a considerable part of the pulse.

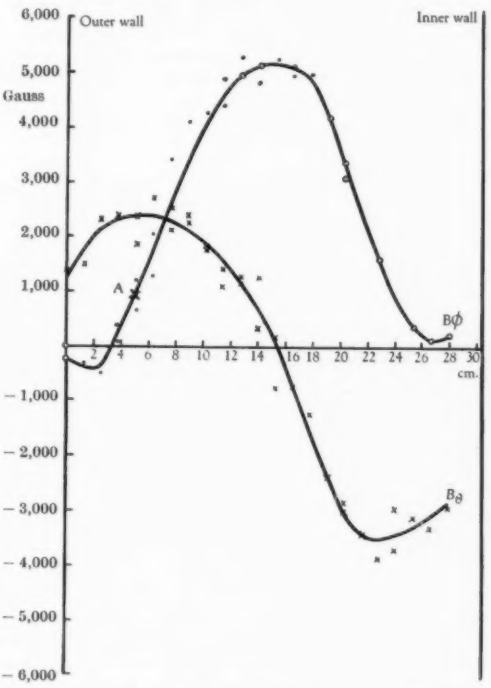

Fig. 6. Average values of magnetic field components B_θ, B_φ as a function of position in discharge tube

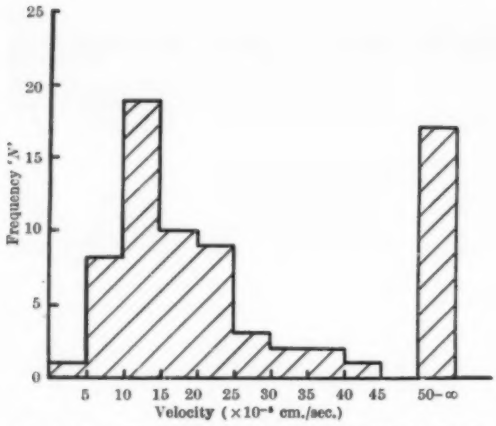

Fig. 7. Histogram showing axial velocity component spectrum. Total No. of minima = 72

Assuming the periodicity, of average value 45 μsec., to be caused by helical motions, a wave-length of 67 cm. is indicated for a velocity of $1 \cdot 5 \times 10^6$ cm./sec. Over the region of the discharge radius studied (4 cm.), the magnetic field wave-length changes from 26 cm. to 175 cm. (from Fig. 6). Thus, the wave-length derived from fluctuations lies within the range expected from the magnetic field helicity. If the perturbation and magnetic field wave-lengths are identified with one another, the variation in time interval between minima in a given discharge may be largely accounted for by lateral movement of the discharge, for the same perturbation velocity.

It may also be noted here that the fluctuations are observed only within a 4-cm. wide annular region of the discharge. Current density plots, derived from the field plots of Fig. 6, show this to be the region of the edge of the discharge current channel. This result, again, bears a resemblance to the result of Sawyer *et al.*[9].

Conclusion

Strong periodic fluctuations in the axial magnetic field component suggest the existence of a helical type of instability near the discharge channel surface. The instability is moving either in the axial direction with an average velocity of $1 \cdot 5 \times 10^6$ cm./sec. or in the azimuthal direction with an average rotational frequency of 2×10^4 c.p.s. or could be a combination of both types of motion. Variation in the fluctuation period during the pulse-time is probably due to general movement of the discharge as a whole.

I wish to thank Messrs. H. B. Mundy and V. C. Cloke for their operation and maintenance of *Sceptre III*. I am grateful to Mr. M. J. Bolton for experimental assistance, to Dr. J. A. Wesson for discussion and assistance with measurements and to Dr. A. A. Ware for his interest and advice on the programme. Thanks are due to Dr. T. E. Allibone, director of the Research Laboratory, Associated Electrical Industries, Aldermaston Court, for permission to publish these results. The work has been supported in part by the United Kingdom Atomic Energy Authority and is in association with the Controlled Thermonuclear Research Programme of the Atomic Energy Research Establishment, Harwell.

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SPECTRAL REFLECTIVITY OF ORE MINERALS

By I. GRAY and Dr. A. P. MILLMAN
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RECENT work in the study of opaque ore minerals under the reflecting ore-microscope, reviewed by Cameron[1], has aimed at their identification by quantitative methods. Two mineral properties in polished sections, namely, reflectivity and microhardness, have been the subject of investigations by Nakhla[2] and Bowie and Taylor[3,4], and it has been found that measurement of these two properties provides a valuable systematic method for the identification of ore minerals.

Although microhardness values are absolute, the published reflectivity data are only relative, since they have been determined by comparison with arbitrary standards the absolute values of which have not been established hitherto. This communication records the establishment of standard absolute values of reflectivity which may be used by other workers for calibration of their equipment, and for standardization of measurements. In addition, the application of a photo-conductive cadmium sulphide cell is described which has been used successfully for measurement of the spectral reflectivity of opaque minerals for different wave-lengths of incident light.

Standardization

Published reflectivity values in white light have been based on pyrite as a relative standard with which other mineral surfaces have been compared. The choice of this mineral as a standard is unsatisfactory, however, due to variation in composition and inherent anisotropy.

For calibration purposes, measurements have been made of absolute reflectivity throughout the spectrum

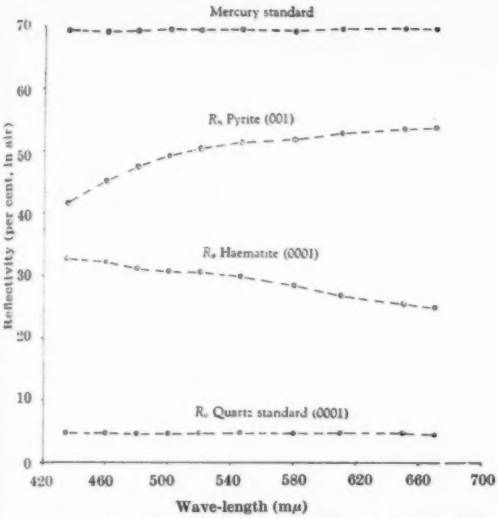

Fig. 1. Spectral reflectivity of quartz and mercury standards, and profiles of pyrite (FeS_2) and h ematite (Fe_2O_3) as determined by the National Physical Laboratory. Computed white-light reflectivity (per cent): mercury, 69·3; pyrite, 52·7; hæmatite, 26·4; quartz, 4·5

for standard reference surfaces. The standards selected were chosen for their reproducibility and permanence, and were: (1) polished basal section of quartz, and (2) natural surface of pure mercury under a glass cover-slip (thickness 0·216 mm., refractive index 1·52). These two standards normally suffice for the photo-conductive cell which gives a linear response. As a check on the linearity of our equipment, two other surfaces were measured; these were (3) natural basal crystal face (0001) of hæmatite, Fe_2O_3, and (4) polished cube face of pyrite, FeS_2.

The reflectivities of these four surfaces, at ten points throughout the spectrum, were determined by the National Physical Laboratory (NPL Reference 0.1959.34), and the results are shown in Fig. 1. The method of measurement employed for each specimen was specular reflexion from an area 0·6 mm. × 0·45 mm. for a cone of radiation, semi-angle 4°, angle of incidence 5°. From these results white-light values were computed which allow for the energy distribution of a tungsten-filament lamp run at a colour temperature of 3,050° K., and for the response profile of the cadmium sulphide cell.

Equipment

The standard values determined by the National Physical Laboratory were used for calibrating our equipment for the measurement of monochromatic- and white-light reflectivity. The apparatus consists of a Mullard ORP.11, cadmium sulphide photo-conductive cell fitted into the Wright ocular of a Cooke, Troughton and Simms ore-microscope. The cell is in circuit with a variable 0–100 V. d.c. energizing source, the current output being recorded on a spot galvanometer. For spectral determinations, Ilford filters of effective band-widths not exceeding 250 Å. are used; the wave-lengths of maximum response of the measuring system allowing for the spectral characteristics of light source, filters and cell are as follows: blue 470 mμ, green 520 mμ, yellow 575 mμ, orange 600 mμ, red 700 mμ. Under standard conditions, with an objective of 0·65 N.A., a 10° cone of incident light, and a stabilized 6 V. 48 w. tungsten-filament light source, the output of the cell varies between 1 μamp. and 5 m.amp. according to the surface measured and wave-length employed.

Results

To illustrate some of the characteristics of spectral profiles of anisotropic opaque minerals, three examples have been selected from the many oriented minerals which have been examined in plane-polarized light.

Fig. 2 shows the spectral profile in the two principal directions of reflectivity, R_o and R_e, in the case of covellite, CuS. At yellow wave-lengths, which approximate to white light, $R_e > R_o$, but in blue, green and red light, $R_o > R_e$ (although to the eye $R_o < R_e$). Moreover, at about 550 and 640 mμ, $R_e = R_o$, that is, the mineral is no longer bireflecting and anisotropic. This 'bireflexion reversal' has not been observed before in opaque minerals due to intensity insensitiveness, and chromatic bias of both the human eye and the conventional selenium photo-electric cell. This phenomenon of reversal is analogous to similar properties of directional refractive index in transparent minerals, based on sign of character of uniaxial or biaxial birefringence. The suggested notation for opaque minerals is 'positive bireflectance', where $R_e > R_o$, and 'negative bireflectance', where $R_o > R_e$.

In Fig. 3, a comparable type of profile is shown for umangite, Cu_3Se_2, with strong absorption at yellow wave-lengths. In this case, however, there is no reversal of bireflectance; minimum bireflectance occurs at 580 mμ. This mineral is particularly interesting since visual estimates of colour and intensity suggest opposite bireflectance at red wave-lengths. Also illustrated in Fig. 3 are the profiles of pyrrhotite, $Fe_{1-x}S$, with higher reflectivity but lower bireflectance. R_o is consistently greater than R_e (negative bireflectance), and maximum reflectivity occurs at green wave-lengths, with absorption towards the blue and red ends of the spectrum.

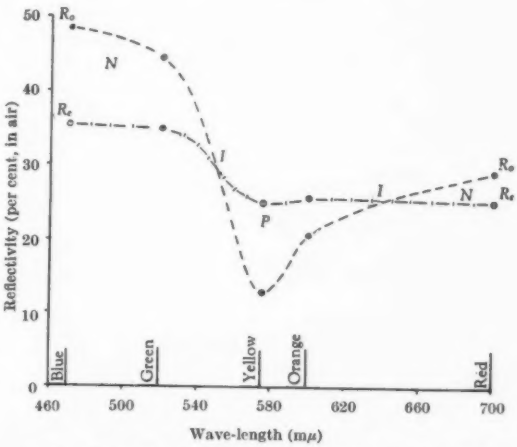

Fig. 2. Profiles of reflectivity R_o and R_e against wave-length in the principal directions of oriented sections of covellite (hexagonal CuS, Sardinia). For R_e, plane of polarization is parallel to c-axis direction; for R_o, it is normal to c-axis direction. White-light values (per cent): R_e, 24·0; R_o, 17·6. Field *N*, negative bireflectance with $R_o > R_e$; Field *P*, positive bireflectance with $R_e > R_o$; *I*, isotropy with $R_e = R_o$

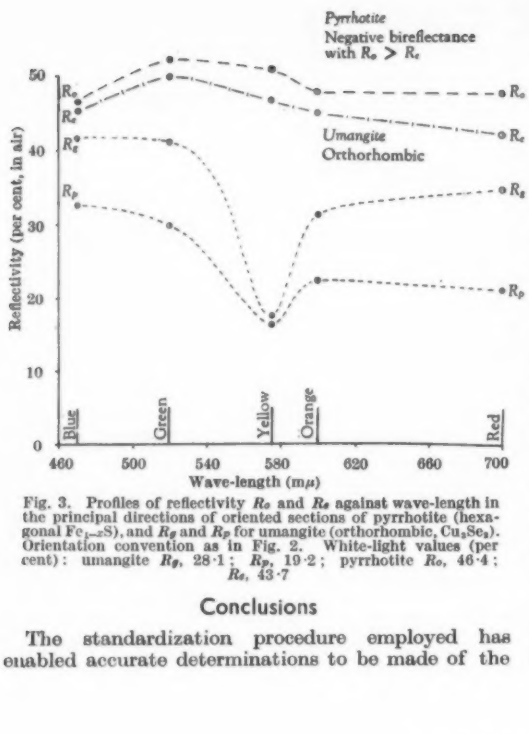

Fig. 3. Profiles of reflectivity R_o and R_e against wave-length in the principal directions of oriented sections of pyrrhotite (hexagonal $Fe_{1-x}S$), and R_g and R_p for umangite (orthorhombic, Cu_3Se_4). Orientation convention as in Fig. 2. White-light values (per cent): umangite R_g, 28·1; R_p, 19·2; pyrrhotite R_o, 46·4; R_e, 43·7

Conclusions

The standardization procedure employed has enabled accurate determinations to be made of the absolute reflectivity in air of oriented polished sections of opaque ore-minerals in both monochromatic- and white-light. The spectral profiles obtained from these measurements show variation in reflectivity, bireflectance magnitude and sign. The insensitivity of the human eye to wave-length intensity coupled with its inherent colour bias cause apparent anomalies in intensity change compared with photo-conductive cell measurements. This is particularly apparent with wide band-width filters using standard comparison methods (visual micro-photometer), and with selenium photo-electric cells which respond in a manner comparable to that of the eye. The fundamental data of absolute reflectivity in white light combined with the characteristics of spectral reflectivity profiles are of great significance in the interpretation of other optical phenomena in polarized light, such as natural colour, spectral dispersion, rotation of polarization plane and conoscopic isogyre effects under crossed Nicols.

The detailed results of this study of the spectral reflectivity of about 200 oriented ore-mineral oxides, sulphides and sulphosalts, and the application of the data and technique to the systematic identification of economic minerals, are to be published in full elsewhere.

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OBITUARIES

Dr. G. H. Francis

Godfrey Herbert Francis died on June 5, at the tragically early age of thirty-two. While climbing in the Lake District he was overtaken by a sudden violent storm and was the victim of a heavy fall of rock, dislodged by lightning.

Francis was born in India on August 11, 1927, and was educated during the War in Adelaide, South Australia. The War and his school-days finished at about the same time; he returned to England and enlisted in the Fleet Air Arm, in which he served for nearly three years. His university career was divided between Oriel College, Oxford (1947–50), where he gained first-class honours in geology, and Clare College, Cambridge (1950–53), where his work on the petrology of the metamorphic complex of Glen Urquhart, Inverness-shire, formed the subject of a successful Ph.D. dissertation. Glen Urquhart lay within a short and convenient distance of his mother's home.

In 1953 Dr. Francis joined the staff of the Department of Mineralogy in the British Museum (Natural History) as a scientific officer; he was one of the two officers in charge of the Museum's collection of rocks. Two years later he was promoted to the rank of senior scientific officer, and continued in that rank until his death. Since he had devoted his three years at Cambridge to an intensive and detailed study of the Glen Urquhart complex, it was only natural that much of his subsequent petrological work of a more general kind should have originated in the particular problems of that region. During his six and a half years in the British Museum he published several papers, both on the rocks of Glen Urquhart and on their metamorphism; he was especially interested in metamorphic facies boundaries, and his original contributions on the subject are worthy of note. It is a matter of regret that his unexpected death left so many of his works incomplete or unpublished; some, including a long paper on "Alkali Metasomatism and its Consequences in Glen Urquhart, Inverness-shire", will be published posthumously.

Dr. Francis was a keen field geologist, and his short career was pleasantly punctuated by three expeditions—to South Peru in 1954 and 1959, and to South Greenland in 1957. The two Peruvian expeditions (the first of which was also his honeymoon) were to study the nepheline-syenite Allinccapac massif, rising to a height of nearly 19,000 ft. in the Province of Carabaya; the purpose of the Greenland expedition was to undertake a study of the same rare rock type in a classic area and to collect specimens of other rocks. All three expeditions resulted in the production of useful topographical and geological maps and (in the case of the 1954 expedition) a paper on the general geology of the area. The Peruvian expeditions also afforded opportunities for archæological work; Dr. Francis published an account of two hitherto unrecorded pre-Columbian villages at Chichacori and Quilliquilli in the gorge of the Río San Gaban, and he collected fine examples of artificially deformed human skulls from mummies of the period.

The little-known mountain ranges of Peru and Greenland were an even greater attraction to Dr. Francis than was the nepheline-syenite, and he made

first ascents in both countries. Indeed, he was a noted climber, having been chosen to take part in another assault on Everest in the autumn of 1953 if the first assault should fail. He was a former member of the Mountaineering Clubs of both his Universities, being treasurer at Oxford, and had undertaken many Alpine climbs of the utmost severity; he sat on the committee of the Alpine Club and was secretary of the Mount Everest Foundation screening committee; his book, "Teach Yourself Mountain Climbing," is the standard work recommended by the British Mountaineering Council, and he had helped edit a guide-book to selected climbs in the Mont Blanc range.

Dr. Francis's quiet and modest manner gave no hint of those qualities which made him such an outstanding leader—initiative, loyalty, courage, perseverance and stamina. His enormous sense of fun helped him to enjoy every aspect of his happy and varied life. He will be greatly missed, both as a scientist and as a friend.

He was married to Gillian Hemens in 1954, and leaves also a son and infant daughter.

A. J. CHARIG

Dr. H. F. Barnes

DR. H. F. BARNES, senior principal scientific officer in the Entomology Department at Rothamsted Experimental Station, died suddenly on February 5, at the early age of fifty-seven. He was at the height of his scientific output, and still full of activity and ideas for the future.

Educated at Bedford School, he obtained his B.A. and M.A. at Oxford, and Ph.D. at London. His work was largely based on the group of Diptera known as gall-midges or Cecidomyidae; but his approach was a very wide one, including their economic status and natural control; their geographical and food-plant range; systematics, including a very close study of biological species and races; their parasites and phenology; and particularly the accurate study of population changes by field measurements. At Rothamsted he assessed the population-levels of two species each year for more than twenty-five years, providing a wonderful basis for the discussion of insect fluctuations and their causes. His work on the group—which covered the whole world—was published in more than fifty papers and seven (out of a contemplated eight) volumes of his "Gall Midges of Economic Importance".

His collection, now in the British Museum (Natural History), was unique in its coverage of the economic species of the whole world and in its long series of hundreds of specimens from different localities and bred from different host-plants. From this material, Barnes was able to solve many questions as to the identity of insects causing similar damage in different countries.

For some years, during the War and after, Barnes took up the study of injurious slugs in Britain, and once more tackled the question of accurate assessment of population and population changes in the field.

He was zoological secretary of the Association of Applied Biologists during 1939–44 and treasurer during 1947–60. He also edited the *Bedford Naturalist* from 1952 until his death. He paid a number of visits abroad, where his reputation was high owing to the world-wide outlook on every problem that he tackled.

On the personal side, I may add that I worked side by side with him at Rothamsted for more than twenty years, and found him a good friend, a stimulating companion and a very loyal colleague.

C. B. WILLIAMS

NEWS and VIEWS

Royal Navy Hydrographic Department: Rear Admiral K. St. B. Collins, C.B., O.B.E.

ON July 7, Rear Admiral K. St. B. Collins was succeeded by Rear Admiral E. G. Irving as hydrographer of the Navy. Admiral Collins has held office for five years in a difficult period of retrenchment and staff reduction which have been imposed upon the Hydrographic Department in common with other branches of the Royal Navy. But despite these reductions, the Department, under Admiral Collins's direction, met, during these years, increased demands for charts from the merchant navies of the world. A new record was achieved in 1957, when 1,404,450 charts were sold, and only a slight reduction in sales, attributable to a world shipping recession, has occurred since that time. As a direct result of his encouragement, Admiral Collins has seen a steadily increasing inflow of reliable oceanic sounding data from many sources so that the world-wide series of oceanic plotting sheets, introduced by his predecessor, Admiral Day, is now increasingly referred to by oceanographers and those interested in the morphology of the ocean floor. These sheets are regularly supplied to the International Hydrographic Bureau for use in the compilation of the General Bathymetric Chart of the Oceans. Admiral Collins has served as chairman of the World Geomagnetic Survey Panel and the Physical Oceanography Sub-committee of the National Committee for Geodesy and Geophysics. He was a member of the National Oceanographic Council and a member of the Executive Committee of the National Institute of Oceanography. He served on the National Committee for the International Geophysical Year. During his period of office, he was able to grant a considerable number of facilities to scientists in Her Majesty's surveying ships, this being in the best traditions of the Surveying Service, while oceanographic tasks for the National Institute of Oceanography, the Department of Geodesy and Geophysics, Cambridge, and the British Museum (Natural History) and other establishments have been increasingly included in Commanding Officers' Hydrographic Instructions. The introduction of electronic aids for fixing the ship while sounding and for base measurement of triangulation onshore have been generally introduced into the Surveying Service by Admiral Collins, and it is for his vigour in introducing those systems that he will be remembered by surveying officers. He was, however, always quick to point out the gross errors that may be introduced into electronic systems by carelessness and insisted that they should be subject to frequent check by well-tried visual methods.

Rear Admiral E. G. Irving, O.B.E.

Rear Admiral Irving, who succeeds as hydrographer of the Navy, joined *H.M.S. Royal Oak* as a cadet in August 1927, afterwards volunteering for the Surveying Service in 1931. Since then he has been constantly employed on hydrographic survey work in many parts of the world, including surveys in Sicily and Italy and in North-West Europe during wartime operations, when he was awarded the O.B.E. and mentioned in dispatches. He has commanded four of Her Majesty's surveying ships and has held the posts of naval assistant to the hydrographer and superintendent of charts in the Hydrographic Department.

Biochemistry at King's College, London : Prof. W. Robson

Prof. William Robson, who is retiring from the chair of biochemistry at King's College in the University of London, is one of London's most senior biochemists. A graduate of King's College, he returned there in 1927 as lecturer in physiological chemistry. He has been a member of the Board of Studies in Biochemistry since its formation in 1929 and was appointed reader in biochemistry at King's College in 1931. In 1958 he became the first professor of the subject at King's. Besides many postgraduate students who have reason to be grateful to Prof. Robson for his encouragement and guidance, many generations of preclinical students in the London medical schools have had their biochemical studies influenced and shaped by his wisdom. In his retirement, Prof. Robson will have the satisfaction of remembering the large part he has played for more than thirty years in rearing and nurturing biochemistry from lusty infancy in the 'twenties to the promising stripling of the 'sixties.

Prof. H. Harris

Dr. H. Harris, who will succeed Prof. Robson, is best known for his contributions to the study of human genetics by the application of biochemical techniques. He graduated in medicine from the Universities of Cambridge and Manchester and then served for three years as a medical officer in the Royal Air Force. He became interested in problems of human genetics during this period, and in 1947 began work with Prof. L. S. Penrose in the Galton Laboratory at University College, London, as a Leverhulme Scholar of the Royal College of Physicians. Dr. Harris was quick to realize the potentialities of chromatography and electrophoresis in genetical studies. His increasing requirements for biochemical facilities were met by his appointment to a joint lectureship in the Departments of Genetics and of Biochemistry. In 1953 Dr. Harris was appointed senior lecturer in the Department of Biochemistry of the London Hospital Medical College. Generous support from the Rockefeller Foundation from 1956 enabled him to expand his field of work. Dr. Harris has also contributed notably to the development of his subject by the production of his two books, "Introduction to Human Biochemical Genetics" in 1953 and "Human Biochemical Genetics" in 1959. These have presented lucid and critical surveys of rapidly expanding research in matters of great human importance.

The Medal of the Iron and Steel Institute

The Council of the Iron and Steel Institute has established a new gold medal award, to be known as "The Medal of The Iron and Steel Institute". This Medal is to be presented on special occasions to societies which have, in the opinion of the Council of the Institute, rendered exceptional service to science or industry over a lengthy period. The first award of the Medal is to be made to the Royal Society, in recognition of its unique service to science over a period of three hundred years. The Medal was presented by the Hon. R. G. Lyttelton, past-president of the Iron and Steel Institute, at the Tercentenary Celebrations of the Royal Society on July 18.

Advisory Council for Research and Development in Fuel and Power

It is announced that the Scientific Advisory Council to the Minister of Power has been reconstituted and its terms of reference amended so as to emphasize that its advisory functions cover all aspects of research and development concerned with fuel and power from the laboratory to industrial application. In order to ensure the co-ordination of the advice which the Minister receives on research and development matters, the Council will take over the functions of the Minister's Fuel Efficiency Advisory Committee. This Committee is accordingly being wound up and the Council is being invited to appoint a standing Committee on Fuel Technology. The members of the Advisory Council on Research and Development are as follows : *Chairman*, Sir Alexander Fleck ; *Deputy Chairman*, Captain (E) W. Gregson ; *Members*, Lieut.-Colonel S. J. M. Auld (oil industry consultant), Dr. C. M. Cawley (chief scientist, Ministry of Power), Mr. T. B. Clark (Imperial Chemical Industries, Ltd.), Sir Josiah Eccles (deputy chairman, Electricity Council), Mr. W. K. Hutchison (deputy chairman, Gas Council), Dr. W. A. Macfarlane (managing director, National Industrial Fuel Efficiency Service), Sir Harry Melville (secretary, Department of Scientific and Industrial Research), Mr. L. Rotherham (member for research, Central Electricity Generating Board), Prof. M. W. Thring (University of Sheffield), Dr. F. A. Vick (deputy director, Atomic Energy Research Establishment, Harwell), Mr. A. H. A. Wynn (scientific member, National Coal Board) ; *Assessors*, Mr. P. Chantler (economic adviser, Ministry of Power), Dr. E. Lee (director, Stations and Industry Divisions, Department of Scientific and Industrial Research), Mr. H. T. Ramsay (director, Safety in Mines Research Establishment, Ministry of Power) : *Secretariat*, Dr. E. N. Eden and Mr. E. W. Prior (Ministry of Power).

The National Council for Technological Awards

The report of the National Council for Technological Awards for the period April 1959–March 1960 records the agreement of the Minister of Education to an amendment of its constitution so as to ensure the inclusion of principals of colleges of advanced technology, and three such principals—Dr. E. C. Edwards, Dr. J. S. Tait and Dr. P. F. R. Venables—have been nominated by the Minister as members (Pp. 26. London : National Council for Technological Awards, 1960). During the year, thirteen courses at six colleges were recognized as leading to the Diploma in Technology, five courses rejected and seven courses referred back. Since September 1956, 100 courses in all, at twenty-three colleges, have been recognized as leading to the Diploma, and of these eighty-nine have commenced, and the number of students attending the first year

of such courses is now 1,558, including forty women students: 129 students gained the Diploma during the year. The Council has set up a Panel, under Sir Walter C. Puckey as chairman, to advise them on industrial training for the Diploma in Technology and the collective responsibilities of the firm and the college in this field. A memorandum setting forth the requirements of the Council, the responsibility of the firm and the responsibility of the college has been issued for the guidance of firms and colleges (Memorandum on the Industrial Training of Students following Courses recognized as leading to the Diploma in Technology. Pp. 11). At the conclusion of a course the firm will be responsible for assessing the extent to which the student has benefited from his industrial training and for certifying to the college that he has completed his training satisfactorily. The college is responsible for certifying to the Council, in the light of this certification, that the student has completed satisfactorily a course of industrial training in accordance with the Council's requirements, as well as for making appropriate arrangements for collaborating with firms and ensuring that where the training is received at more than one firm the complete scheme of training followed complies with the statement of the broad nature and sequence of training required for the particular course. The Council has also issued a List of ninety-five courses at twenty-three colleges which are now recognized as leading to the Diploma in Technology (List No. 11. Diploma in Technology. Pp. 5).

Polar Research in the U.S.S.R.

THE first Arctic drift expedition, led by I. D. Papanin, took place in 1937–38. Six expeditions of the same type followed, and since 1954 drifting Arctic stations are a constant feature of the regular survey. Recent progress of this work is reviewed by P. A. Gordienko (*Priroda*, **6**, 35; 1959), while recent progress in the oceanography studies in the Arctic is described by A. F. Treshnikov (*Priroda*, **2**, 25; 1960), especially all the work done on the distribution of currents, temperature, chemistry and biology of the Arctic Ocean as influenced by the submarine Lomonosov ridge. The work of the Antarctic expedition of the Academy of Sciences is constantly under review. K. A. Brodsky, K. K. Markov and V. I. Shilnikov (*Priroda*, **7**, 19; 1959) give a summary account of the geographical zonality at high latitudes of the southern hemisphere. It is provided with a map in colour and several sections illustrating the distribution of temperature and salinity in the different parts of the ocean. The glacial cover of the Antarctic, as determined by the seismic survey, is discussed by Y. M. Model and A. V. Nudelman (*Priroda*, **11**, 93; 1959), who have assembled together the results of the various national expeditions. They give an outline structural map of the Antarctic continent with indications of the probable mountain ranges and rift troughs.

International Bird Preservation

IN its annual report for 1959 the British Section of the International Council for Bird Preservation announces the additions of the U.S.S.R., Portugal and Malaya to the national sections of the Council, bringing the total number of subscribing countries to forty-eight. Another important event has been the setting up of a special sub-committee of the British Trust for Ornithology to investigate the injurious effects of pesticides on wild life. Reference is made to the mass destruction of small birds in Italy to be served up as savoury dishes to tourists. Individual tourists, it is claimed, can do much to eliminate this practice by expressing their displeasure and disgust when they see small birds served in restaurants. The Indonesian authorities are trying to control the clandestine traffic of birds of paradise plumes between New Guinea and Singapore. These beautiful birds face the threat of destruction while their plumes are in demand for purposes of personal adornment. The report also points out that, while Lord Ilchester was one of the first to raise the question of oil pollution of the sea in the House of Lords nearly forty years ago, the evil still persists. When the International Convention for the Prevention of the Pollution of the Sea by Oil came into force on July 26, 1958, eleven maritime countries had ratified; on March 2, 1959, Finland ratified, thus bringing the total up to twelve. It has since been announced that the United States has also accepted the International Convention, though with certain technical reservations. The report of the British Section may be obtained from the International Council for Bird Preservation, c/o British Museum (Natural History), Cromwell Road, London, S.W.7, price 3*s*.

South Australia Museum

THE annual report for 1958–59 of the South Australian Museum in commenting on the field work accomplished describes the search for Tertiary mammalian records in the Lake Eyre Basin (Pp. 15. Adelaide: Government Printer, 1960). This was a joint expedition with the University of California and enabled a clearer picture to be obtained of the stratigraphy of the region than had been possible before. Several other expeditions were arranged, and such activities should be an incentive to museums in Great Britain to conduct similar work in spite of the financial position. The Cave Exploration Group has undertaken further work at the Specimen Cave, Naracoorte. An underwater research group has also been formed and is being fostered by the museum. Its activities—in which many members of the staff take part—has added many specimens to the marine collections.

Classification of Pharmaceutical Preparations

BECAUSE of the toxic or dangerous nature of many pharmaceutical preparations, special regulations are necessary to prevent risks of poisoning and other risks to which they may give rise. Trade in pharmaceutical preparations must be controlled, and for this purpose a classification of such preparations must be established. Twenty years ago it was relatively easy to establish such a classification, but since then hundreds of new preparations have been put on the market, and earlier systems of classification do not fully satisfy present requirements. The principles which inspired or still inspire such classifications vary from country to country. These regulations contain two common elements: certain pharmaceutical preparations may be supplied only against a medical prescription, and some may be sold only by pharmacists. Despite these common factors, the regulations of different countries vary considerably so that any possible attempt at obtaining uniformity is beset with difficulties. A survey of comparative health legislation based on health laws and regulations published in the *International Digest of Health Legis-*

lation, which prescribes the various systems of classification of pharmaceutical preparations in ten or more countries, brings out the divergences in these different regulations (World Health Organization. Classification of Pharmaceutical Preparations: a Survey of Existing Legislation. Pp. 56. (Geneva: World Health Organization; London: H.M. Stationery Office, 1960.) 2 Swiss francs; 3*s*. 6*d*.; 0.60 dollar).

Bacterial Population of the Nose and Skin

The frequent occurrence of penicillin-resistant *Staphylococcus aureus* in the noses of those working in hospitals and in penicillin factories has been shown to be related to the presence of penicillin in the environment. H. Williams Smith and W. E. Crabb of the Animal Health Trust Farm Livestock Research Centre, Stock, Essex, decided to determine whether the common practice of feeding pigs and chickens continuously on diets containing antibiotics influenced the *Staph. aureus* population of the nose and skin of the animals and that of their attendants in a similar manner (*J. Path. and Bact.*, **79**, No. 2, April 1960). They compared farms where antibiotic feeding was practised with farms where antibiotic feeding had never been employed. The approach was indicated to a considerable extent by current agricultural practice. For example, they were unable to examine as many penicillin-fed pigs as they would have wished because in Great Britain the penicillin additives in pig foods have been largely superseded by tetracycline additives; on the other hand, in chickens it was possible to study the effect of feeding with penicillin and chlortetracycline or oxytetracycline together, for it is customary to include penicillin with one or other of the tetracyclines in most antibiotic-supplemented poultry foods. The investigations showed antibiotic-resistant strains were much more prevalent on animals maintained on diets containing antibiotics than on animals maintained on diets that did not contain antibiotics. This applies also to their attendants. Phage typing and other tests showed that the antibiotic-resistant strains isolated from the attendants were usually identical with those isolated from their animals.

Controlling Rats in Sewers

Local authorities in Britain have had varying success in their efforts to rid their sewers of rats. Until recently, the feeling has been growing that a mere reduction in the average level of infestation was the most that could be achieved, and that this was a poor return for all the effort expended. During the past year or so, the introduction of new methods of control directed the way to further progress, and a growing number of authorities are reporting very satisfactory results, several having achieved complete clearances. A Technical Bulletin prepared by Dr. E. W. Bentley, of the Ministry of Agriculture, Fisheries and Food, has been written to try to foster this trend (No. 10: Control of Rats in Sewers. Pp. iii+22+4 plates. London: H.M. Stationery Office, 1960. 2*s*. 6*d*. net). It describes certain features of the ecology and behaviour of rats in sewer systems and the several ways by which control can be brought about; its main emphasis is on the need for effective planning.

Television Field Trials

The future of the television services of Great Britain is kept under constant review by the Postmaster-General and his Television Advisory Committee. The latter in turn has a Technical Sub-Committee, which has been asked to consider the relative merits of the 405-line transmission used in Britain, and the 625-line system now in general use in Europe. Consideration has also been given to the possibilities of colour television and to the best direction in which to develop the higher frequency bands IV and V when these are available. To assist the sub-committee in its task, a working party was established to organize and conduct field trials designed to give technical data on the performance of some of the systems concerned. These trials were carried out during 1957–58, and in view of the importance of the scientific and technical results obtained, these are now made generally available in a report published by the British Broadcasting Corporation (Television Field Trials of 405-Line and 625-Line Systems in the UHF and VHF Bands, 1957–1958. Pp. 152. London: British Broadcasting Corporation, 1960. 20*s*.).

The first part of the report gives the results of field trials of 405-line television in bands I and V, using frequencies of about 45 and 650 Mc./sec., respectively. These show that the service area is more limited at the higher frequency, and is subject to greater irregularity in hilly terrain. It is therefore evident that a greater number of transmitters would be required for a band V service than is at present used in band I. In the second series of trials described in Part 2 of the report, a comparison was made between 405-line television in band I with 625-lines in band V. In areas where adequate field strength prevailed, the band V pictures were slightly better. The appendixes to the report contain a large number of diagrams illustrating in considerable detail the various features, subjective as well as objective, of the results obtained in these extensive trials.

New British Analogue Computer

In a recent issue of *Nature* (**186**, 201; 1960) the first British digital-analogue computer, the *Corsair*, was described. Now a second machine of digital-analogue type has been introduced by the Redifon Company. The new Redifon machine differs completely in concept from the *Corsair*, since the actual calculations are performed exclusively by analogue techniques. Even multiplication, which is notoriously unsatisfactory using an analogue device, is treated in this way. The digital part of the machine lies in its input–output device which makes use of magnetic tape upon which information is recorded by a machine of standard keyboard and through which information can be obtained via a typing device of the sort used in adding machines. The magnetic tape store which is associated with the *Radic* system, as it is called, has a number of novel features, including the interesting one that the magnetic tape is perforated with sprocket holes and apparently moves discontinuously. This technique makes such operations as the serial correlation of recorded data particularly easy, and will undoubtedly result in the *Radic* computer filling a niche which previous analogue computers have failed to do.

Interstellar Extinction and Polarization

The study of the particles in interstellar space is important for two reasons. First, interstellar dust produces absorption of light, and makes difficulties for astronomical distance determination. Secondly,

the discovery of interstellar polarization by Hall and Hiltner indicated the existence of a general galactic magnetic field, and one would like to determine the strength and direction of this field. H. C. van de Hulst studied the scattering of light by homogeneous spheres, and from the observed extinction concluded that the interstellar grains are dielectric, and are about 1μ in size. The grains must be asymmetric in shape to produce interstellar polarization, and the relation between the observed polarization and extinction will depend on the shape of the particles. It would be an improvement if the theory could be based on scattering by long cylinders. R. Wilson (*Mon. Not. Roy. Astron. Soc.*, **120**, 51; 1960) has recently published an approximate solution of this case for refractive index near unity. Extinction curves have been computed for different degrees of polarization; it is predicted that the colour excess per unit mass and the ratio of the total to selective extinction will both depend on the polarizability. The predictions are compared with observation, and confirmation is obtained of the existence of a general galactic magnetic field aligning the interstellar grains by a mechanism of paramagnetic relaxation as proposed by L. Davis and H. L. Greenstein. The new expression for the ratio of total to selective absorption may lead to substantial revisions in the distances of some of the more distant stars.

Abundance of Marine Plankton

An unusual and worthwhile statistical study of the abundance of marine plankton has been made by R. M. Cassie in the March issue of the *New Zealand Journal of Science*. He has analysed the results from a transect of sixty stations starting in the open sea and passing through a zone of mixed water into harbour water. Partial and multiple regressions were calculated, relating the abundance of each species to that of five other species, to temperature and to salinity. The regressions accounted for much of the variation, but the residuals were not randomly distributed, so that the interpretation of the results is necessarily inconclusive. It is inevitable that the results of one day's sampling should be suggestive rather than informative, but the technique which Cassie has described is likely to prove most useful in the quantitative study of the relationships of animals and plants to each other and to their physical and chemical environment.

Pelagic Polychaetes of the South Atlantic

The samples collected since 1925 during the Discovery Investigations of the southern oceans continue to provide fruitful material for studies of systematics and zoogeography. In Discovery Reports (**30**, April 1960), Mr. N. Tebble has made a study of the pelagic polychaetes. A systematic account is given of the twenty-nine species recorded in the South Atlantic; this is followed by a description of the distribution of these species in relation to the environment. Only three species were found to be endemic to the Antarctic zone, while sixteen were found only to the north of the Sub-Tropical Convergence. Of the remaining species, four were cosmopolitan in distribution. The results conform to the usual pattern of plankton distribution in the South Atlantic with a few species occurring in large numbers in the Antarctic zone and a great variety of species forming a small standing crop in the sub-tropical and tropical zones.

Research Committee on Archæological Field Experiments

Excavators have long had to deal with the setting up of ditches, soil creep and other similar phenomena. They also have to notice the activities of worms which have frequently considerably altered the original soil structure. Too little has been known about these matters, and at the Glasgow meeting of the British Association in 1958 a discussion on the natural processes leading to the burial of archæological remains was inaugurated. This led to the formation of a Research Committee which made preliminary investigations. The idea, now, is to start in a chalk down environment and to make there a simple earthwork which can be kept under review for a long period of time. Later similar projects in sandy and clayey situations will be undertaken as funds allow. The first site selected is near the summit of Overton Down near Marlborough, on the Fyfield Down reserve of the Nature Conservancy. After the earthwork is made a careful study at regular intervals will be undertaken so that more exact data relating to the infilling of the ditch and the weathering of different kinds of objects can be obtained. Only those with permits will be allowed on the site and no cars will be permitted anywhere near it. It is hoped in this way to learn something of the mechanics of these well-known phenomena in a chalk down milieu.

U.S. Gas Chromatography Research Center

A new Gas Chromatography Research Center, the first of its kind, has been established by the Barber-Colman Co., at Houston, Texas. The primary function of the Center will be new instrument development and evaluation of component parts and accessories. This will include the development of laboratory chromatographs, portable chromatographs, process monitors and custom instruments, as well as refinement of argon and flame ionization detectors, sample injection devices and other accessory designs. Further information can be obtained from Ad. Auriema, Inc., 85 Broad Street, New York 4, N.Y.

Analytical Chemistry and Applied Spectroscopy at Pittsburgh

The twelfth Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy will be held at the Penn-Sheraton Hotel in Pittsburgh, Pennsylvania, during February 27–March 3, 1961. About 150 papers will be presented on all phases of analytical chemistry and spectroscopy. A symposium entitled "New Frontiers in Optics and Spectroscopy" will be sponsored jointly by the Pittsburgh Conference and the Optical Society of America. Original papers are invited on all phases of analytical chemistry, spectroscopy, and nucleonics applied to analysis. The final date for receipt of abstracts is October 15. Further information can be obtained from Dr. William F. Harris, Research Laboratories, Westinghouse Electric Corporation, Pittsburgh 35, Pennsylvania.

The Night Sky in August

Full moon occurs on Aug. 7d. 02h. 41m. U.T., and new moon on Aug. 22d. 09h. 16m. The following conjunctions with the Moon take place: Aug. 3d. 18h., Jupiter 5° S.; Aug. 5d. 01h., Saturn 4° S.; Aug. 15d. 14h., Mars 4° N.; Aug. 15d. 17h., Aldebaran 0·3° S.; Aug. 31d. 01h., Jupiter 5° S. In

addition to these conjunctions with the Moon, Mercury is in conjunction with Pollux on Aug. 5d. 17h., Mercury being 8° S., Venus with Regulus on Aug. 8d. 14h., Venus being 1° N., and Mars with Aldebaran on Aug. 17d. 12h., Mars being 5° N. Mercury is a morning star, and during the second week of the month it is favourably situated for observation. It rises at 3h. 00m. on August 13, about 1h. 40m. before the Sun; the stellar magnitude of Mercury is −0·6 on this date. Venus is too close to the Sun for observation. Mars rises at 23h. 20m., 22h. 50m. and 22h. 20m. at the beginning, middle and end of the month, respectively. It is in Taurus, passing 5° north of Aldebaran on August 17; its stellar magnitude is +0·7 and its distance from the Earth in the middle of the month is 120 million miles. Jupiter sets at 0h. 50m., 23h. 45m. and 22h. 45m. on August 1, 15 and 31, respectively. In Ophiuchus, its stellar magnitude is −2·0 and its distance from the Earth on August 15 is 430 million miles. Jupiter is prominent low in the southern sky after sunset, but conditions are not particularly favourable for observation. Saturn is in Sagittarius, east of Jupiter, setting at 2h. 15m., 1h. 10m. and 0h. 05m. on August 1, 15 and 31, respectively. Its stellar magnitude is +0·5 and its distance from the Earth on August 15 is 860 million miles. Occultations of stars brighter than magnitude 6 are as follows, observations being made at Greenwich: Aug. 8d. 22h. 05·9m., λ Aqr. (*R*); Aug. 15d. 02h. 46·2m., 179 B.Tau. (*R*); Aug. 17d. 2h. 51·6m., 130 Tau. (*R*). *R* denotes reappearance. The Perseid meteors are active during the first half of the month, but conditions are unfavourable for observation.

University News: California

Prof. George M. Briggs, executive secretary of the Biochemistry and Pharmacology Training Committees, Division of General Medical Sciences, National Institutes of Health, has been appointed chairman of the Department of Nutrition in the College of Agriculture at the University of California at Berkeley. Before joining the National Institutes of Health, Prof. Briggs was an associate professor of poultry nutrition at the University of Minnesota, St. Paul, Minnesota, and a professor of poultry nutrition at the University of Maryland, College Park, Maryland.

Canberra

Prof. L. G. H. Huxley has been appointed vice-chancellor in succession to Sir Leslie Melville. Until the end of 1959 Prof. Huxley was Elder professor of physics at Adelaide University.

Rockefeller Institute

Dr. Edward H. Ahrens, jun., and Dr. James G. Hirsch have been promoted to professors and members of the Rockefeller Institute. Dr. Ahrens has been a pioneer in the research on lipids, and was promoted to associate professor at the Institute in 1955. He is also chairman of the Metabolism Study Section of the U.S. Public Health Services. Dr. Hirsch in recent years has been investigating the role of white blood cells in host resistance to infection, and has been concerned with the discovery of phagocytin.

Southampton

The Council of the University has gratefully received from the Ford Motor Co., Ltd., a contribution of £5,000 to the 1962 Centenary Appeal Fund. The title of reader has been conferred upon Mr. A. T. Patterson (history) and Dr. W. H. Cockcroft (mathematics). Mr. H. C. Tottenham has been appointed to the readership in structural engineering (Department of Civil Engineering). The following new appointments have been made: H. S. Allen (lecturer in civil engineering), C. H. B. Mee (assistant lecturer in physics).

Announcements

Prof. Alexander Robertson, emeritus professor of organic chemistry in the University of Liverpool, has been appointed a member of the Agricultural Research Council arising from the appointment of Prof. E. G. Cox as secretary to the Council.

Dr. T. F. West has been appointed editor of *Chemistry and Industry*, the weekly journal of the Society of Chemical Industry. Dr. West is at present editor of *Pyrethrum Post* and the author of the standard work on DDT, of a treatise on chemical control of insects and of a book on synthetic perfumes. He was for some years a director of Drug Houses of Australia, Ltd.

Mr. G. D. Speake has been appointed deputy chief of research at Marconi's Research and Development Laboratories, Great Baddow, near Chelmsford, Essex. Mr. Speake joined Marconi's Wireless Telegraph Co., Ltd., in 1950, when he was engaged in radar systems research. In 1954 he was appointed chief of the Vacuum Physics Section of the Research Division, and two years later he became chief of the Microwave Physics Section.

The Research Study Group, which was appointed to study the need for further research into the effects of the use of toxic chemicals in agriculture and food storage, has begun its inquiries. The Group is prepared to receive written evidence of views on the subject of the inquiry from persons or organizations. Written evidence should be addressed to the secretary of the Group, Dr. E. J. Miller, Plant Pathology Laboratory, Hatching Green, Harpenden, Herts.

The British Society of Rheology will be holding a meeting on "Rheology of Polymers" at Swansea during September 8–10. Further information can be obtained from Dr. M. F. Culpin, 8 The Broadway, Pontypool, South Wales.

The 1960 International Conference on Nuclear Structure will be held at Kingston, Ontario, Canada, during August 29–September 3. Further information can be obtained from R. L. Graham, Atomic Energy of Canada, Ltd., Chalk River, Ontario.

The first International Symposium on "Cori' Ester and Phosphorylated Glucides" will be held at the Museo della Scienza e della Tecnica, Milan, during September 16–18. Further information can be obtained from the Secretary of the organizing committee of the Symposium, Via Modica 6, Milan.

An International Symposium on "Data Transmission" is being sponsored by the Benelux Section of the Institute of Radio Engineers in co-operation with Het Nederlands Radiogenootschap and the Institute of Radio Engineers Group on Communications Systems, at the Technische Hogeschool during September 19–21. Further information can be obtained from B. B. Barrow, secretary of the Benelux Section, Institute of Radio Engineers, Postbus 174, Den Haag, Nederland.

THE ROYAL SOCIETY: APPOINTMENTS AND AWARDS

THE Council of the Royal Society has appointed Dr. J. Seed, of the Department of Radiotherapeutics, University of Cambridge, to a Foulerton Gift research fellowship as from October 1, to enable him to carry out an investigation of the control mechanisms of nucleic acid and protein synthesis in normal and tumour cells, with particular reference to the actions of ionizing radiations in radiotherapy at the Department of Radiotherapeutics, University of Cambridge. The Council has also appointed Dr. D. T. Edmonds, of the Clarendon Laboratory, University of Oxford, to a Mackinnon research studentship as from October 1, to enable him to carry out magnetic investigation below 1° K. in large magnetic fields at the Clarendon Laboratory, Oxford.

The Committee representing the Royal Society and the Armourers and Brasiers' Company has appointed Dr. J. H. Brunton, of the Laboratory for the Physics and Chemistry of Solids, Cavendish Laboratory, Cambridge, to the Armourers and Brasiers' research fellowship as from October 1, to work on deformation characteristics of base metals at very high rates of strain, at the Laboratory for the Physics and Chemistry of Solids, Cavendish Laboratory, Cambridge.

Awards under the Royal Society and Nuffield Foundation Commonwealth Bursaries Scheme have been made to the following: Dr. S. M. Bromfield, of the division of plant industry of the Commonwealth Scientific and Industrial Research Organization, Canberra, to assist him in visiting the Macaulay Institute for Soil Research, Aberdeenshire, for ten months from October, in order to develop his studies of processes affecting the availability of phosphorus to plants; Dr. J. A. Friend, senior lecturer in physical chemistry, University of Tasmania, to assist him in visiting the University of Reading for a year from January 1961, to enable him to study experimental techniques for the precise measurement of heats of mixing; Prof. I. Lauder, associate professor of chemistry, University of Queensland, to enable him to study 'ion-molecule' reactions by mass spectrometry at the University of Leeds, for six months from October 1960; Mr. W. V. Lewis, university lecturer in geography, Cambridge, to assist him to visit the Arctic Institute of North America, Montreal, for five months from April 1961, in order to study 'permafrost' areas, and areas once covered by large continental glaciers; Prof. H. McLennan, associate professor of physiology, University of British Columbia, to enable him to extend to invertebrate material, his studies on the chromatographic characteristics of an inhibitory principle present in mammalian brain, at University College, London, during June–July; Prof. H. B. Rycroft, director of the National Botanic Gardens of South Africa, and Harold Pearson professor of botany in the University of Cape Town, to assist him in completion of study of the genus *Protea* at the Royal Botanic Gardens, Kew, and elsewhere in the United Kingdom, for six months from July.

Awards of grants by the Paul Instrument Fund Committee have been made as follows: £1,000, in supplement of a previous grant to Prof. J. D. McGee, professor of instrument technology, Imperial College of Science and Technology, London, for the construction of a television system for X-ray image intensification; £500, in supplement of a previous grant, to Dr. H. Motz, Donald Pollock reader in engineering science, University of Oxford, for the construction of a linear accelerator working at 1·6 cm. (*J*-band); £3,230, in supplement of a previous grant, to Dr. P. M. B. Walker, Royal Society research fellow, department of zoology, Ashworth Laboratory, University of Edinburgh, for the construction of a high-speed integrating microspectrophotometer, to facilitate the analysis of biological cells or liquid droplets of the order of 10^3 cubic microns volume.

AUSTRALIAN BREAD RESEARCH INSTITUTE LABORATORIES

DR. D. A. CAMERON, Minister for Health and Minister-in-Charge of the Commonwealth Scientific and Industrial Research Organization, Australia, opened the new laboratories of the Bread Research Institute at North Ryde, a suburb of Sydney, on May 16. Dr. Cameron said that it was good to see such an excellent relationship between the bread manufacturers, who had started the Institute, and the Government which contributed to its costs through the Commonwealth Scientific and Industrial Research Organization. Mr. W. Sloan, president of the Council of the Institute, remarked that the occasion was being attended by bakers from every State in Australia and from New Zealand.

The new Institute comprises laboratories covering some 14,000 sq. ft., on a three-acre site at North Ryde which was made available by the Organization. The total cost of the building was about £75,000 of which £30,000 was contributed by the Organization. During the past thirteen years the Institute has been housed in laboratories in Pacific Highway, North Sydney, which it has now outgrown. The new site will allow room for expansion, and has the advantage of being in close proximity to the laboratories of the Organization's Division of Food Preservation and Transport, now under construction.

The Bread Research Institute was established in New South Wales in 1947 following the Kinsella inquiry into the bread industry. The noted British cereal chemist, Dr. D. W. Kent-Jones, went to Australia in 1947 to advise on the establishment of the Institute. In 1950, it was recognized by the Commonwealth Scientific and Industrial Organization as an industrial research association, and now receives an annual grant from the Organization, related to its industrial income. This year the grant will be about £15,000.

With funds made available from the Wheat Industry Research Council, the Organization has recently established a small Wheat Research Unit for bio-

chemical investigations of wheat quality. The Bread Research Institute has agreed to house this unit in its new laboratories and the director of the Institute will act as officer-in-charge of the unit.

The work of the Institute has had a very marked effect in improving the standards of the baking industry, and is recognized by bakers throughout Australia, with whom it keeps in close touch. It has provided a testing service for flour and other raw materials used in the industry, and by means of demonstrations by travelling bakers and a series of newsletters and publications it has brought knowledge and practical advice to bakeries throughout the country. It has also built up an important programme of fundamental research in various aspects of wheat and flour quality, the properties of doughs and other subjects. This work has been done in close association with the Organization, the State Departments of Agriculture and some of the universities.

The Institute's influence now extends strongly to the flour milling industry, where its work has been largely responsible for the establishment of standards of flour quality. This has been important to the bread industry, which is thus enabled to insist on definite quality specifications for the flour it buys and has been particularly important for building up the export trade in wheat and flour. The Department of Trade and the Australian Wheat Board have called extensively on the services of the Institute in this connexion, and officers of the Institute have visited Japan and other countries in the East and Middle East to advise on the use of Australian wheats.

U.K. ATOMIC ENERGY RESEARCH ESTABLISHMENT: WANTAGE RESEARCH LABORATORY

By B. S. SMITH

Head of the Isotope Research Division

AFTER about ten years successful expansion of the production, sales and use of radio isotopes, United Kingdom Atomic Energy Authority decided to reorganize its isotope research and production so as to encourage the further expansion of the use of isotopes which may be expected in the next few years. The irradiation of the raw materials will continue to be carried out in the Authority's nuclear reactors at Harwell, Calder Hall and Chapelcross. The preparation of isotopes, the synthesis of labelled compounds, and the marketing are being concentrated at the Radiochemical Centre at Amersham. Research on the applications of radio isotopes and on the use of radiation has been concentrated in the Isotope Research Division of the Atomic Energy Research Establishment. The new laboratories of this Division are at Wantage, and were formally opened by Lord Hailsham on May 16. In these laboratories the Authority has created a focal point where extensive facilities for work with isotopes and radiation sources are being used by about two hundred scientists, half of which are graduates in a wide variety of disciplines.

As the nuclear power programme develops, almost unlimited quantities of radiocæsium will become available, and one of the tasks of the Division is to examine the uses of massive radiation sources. The high cost of a plant to extract and encase cæsium from fission products makes it more economical to use cobalt as an irradiation source until such time as the demand justifies the construction of a large chemical separation plant. Fortunately, the nuclear power programme can provide as a by-product considerable quantities of radiocobalt, and it is this cobalt which will be the basis of the radiation programme for some years.

There are twenty-three large versatile irradiation cells in use. They are concrete shielded rooms in which the experimental apparatus can be set up under radiation-free conditions, and then irradiated by a pre-determined configuration of sources. The source strengths at present in use range from 100 to 10,000 curies, and several of the cells are temperature controlled.

In the radiation chemistry field, investigations have been concentrated on such chain processes as polymerization, oxidation and halogenation. The effects of radiation on catalysts are also being studied. In the food and medical applications section, the use of radiation for sterilization of equipment is giving encouraging results, particularly in expanding the use of plastic materials which are unsuitable for heat sterilization. A study is being made on the use of radiation for the control of *Salmonella* in frozen eggs, desiccated coconut, and imported cattle feed with a high protein content. The plant genetics section has been studying the external factors which influence the radio-sensitivity of plants and the conditions under which radiation can be used to break down the interspecific incompatibility.

The Laboratories have a small animal house for testing food and pharmaceuticals for possible toxicity, glass houses and trial beds for the plant genetics work, and constant temperature rooms for insect culture.

To gain experience at the pilot stage of projects, and to allow manufacturers to carry out extensive trials, a package irradiation plant has been built in conjunction with the Owen Organization and is at present undergoing proving trials. The plant permits the automatic handling of standard packages ($14 \times 12 \times 9$ in.) through an irradiation field providing a dose of 10,000 rads to 5 megarads, according to the rate of traverse. The capacity of the plant is about 100 cu. ft. a day at a sterilizing dose of 2·5 megarads, and larger quantities at lower total doses. The plant is initially loaded with 150,000 curies of cobalt-60 and the cost of giving 1 cu. ft. of material a dose of 2·5 megarads is about 15*s*. This cost will be considerably reduced in plants designed for a special purpose. It is planned to rent four-fifths of the capacity of this plant to industrial concerns, and although it is not yet in operation its capacity has already been oversubscribed.

The Laboratory also operates an irradiation pond at Harwell. This uses the high gamma flux available from the spent fuel elements from the *Dido* and *Pluto* research reactors. It consists essentially of a

water pond 20 ft. deep with facilities for mounting the freshly discharged fuel elements in a lattice containing a number of irradiation positions. The material to be irradiated is placed in watertight cylinders (3⅝ or 7¼ in. diam. and 30 or 48 in. long) which are then lowered through the water shield to the irradiation position. The pond usually contains more than a megacurie of fuel element activity and will give up to 4 megarads/hr. in the small irradiation cans. The present charges for irradiation in this unit work out at about 10*s*. per megarad to a cubic foot of material.

In addition to the cobalt and fuel element sources, there is a 4-MeV. linear accelerator with a 2-kW. electron beam output. It is used principally for treating small samples to high dose-levels of the order of 10^8 rads and also to study dose-rate effects. It gives dose-rates a hundred times higher than those available from the gamma cells.

The Division has medium-level and tracer-level chemical laboratories. The fields covered are wide and include the incorporation of isotopes in colloids for medical studies, improved methods of synthesis of labelled compounds, the use of autoradiography as an analytical tool in metallurgy, and the operation of an activation analysis service for other laboratories.

In the physics laboratory a section works in close collaboration with the National Physical Laboratory and other national laboratories on the absolute measurement of radioactivity. It has established standards of radioactivity and issues standards for many isotopes not yet covered by the standards service of the Radiochemical Centre. The work on instruments and radiation detection is largely directed towards widening the fields of application of gauges using radioactive sources and increasing the sensitivity and discriminating powers of detectors so that tracer uses of isotopes can be extended without increasing the quantity of isotope used.

An essential feature of the work of the Research Laboratory is to discover those industrial processes and fields of industrial and academic research where advantages can be gained by the introduction of instruments or techniques using radioactive materials. An experimental and advisory service is operated which will visit firms and discuss general and particular problems, and on a payment basis will make special investigations either on the firm's premises or back in the laboratories. To further this objective, exchange visits are made with the research associations of many trades, and the Department of Scientific and Industrial Research has attached a small group which uses the facilities of the laboratories and acts as a further contact with research and industry.

For a fixed capitation fee, firms can attach a scientist to the laboratory to work on a problem of either general or commercial interest. In this way a satisfactory blending of the skills of the firm in its own field with the facilities and experience of the Laboratory is achieved.

No outline of the facilities of the Laboratory would be complete without mention of the Isotope School. It was first set up at Harwell in 1951 to give basic training in the uses of radioisotopes in research, industry, and medicine. It is open to students from all countries, and provides a basic four-weeks' course several times a year, together with a number of courses on specialized subjects such as medical applications, radiological protection and autoradiography.

PROTECTION AGAINST TIDAL FLOODING IN LONDON

MEMORIES of the effects on the east coast of Britain of the disastrous storm surge of January 31–February 1, 1953, are beginning to dim. A Government report[1], which has recently been published, is therefore a timely reminder that in the vitally important London area there is no justification for complacency concerning the present degree of protection against tidal flooding.

It is true that in 1953 the low-lying areas of London escaped flooding, but the water lapped the top of the defences at many points so that the margin of safety must have been very small. Thus the question might well be asked as to how it is that seven years afterwards the defences of London are still virtually the same, whereas at almost all other vulnerable points on the east coast of Britain they have been greatly strengthened. As will be seen, the explanation lies in the complexity of the problem and the high capital cost of a solution.

In 1953 the maximum level of the surge-cum-tide at London Bridge was 6 ft. above predicted high water. When considering the possibility of a future even higher maximum level, there are four significant features of the 1953 event which should be borne in mind: (*a*) the river discharge was low—only 2,600 cu. ft./sec.; (*b*) the normal tide on which the surge was superimposed was a spring tide, but not a particularly high one; (*c*) the peak of the surge did not coincide with the time of predicted high water, but preceded it by about 2 hr.; (*d*) considerable breaching and overspill into low-lying areas occurred farther down the estuary.

Any of these features could have been more adverse, in addition to which the magnitude of the surge itself might have been slightly greater. In order to investigate these possibilities, tests were carried out on a hydraulic model[2] of the Thames estuary. It was deduced that a major river flood of 20,000 cu. ft./sec. would have raised the 1953 level by 9 in.; also that an increase of 1·5 ft. in the surge height at Southend (or a correspondingly less favourable phasing with tide) would have added about 1·7 ft. at London Bridge, while a 3 ft. increase would have added about 3 ft. at the same point. The relief due to storage in low-lying areas was shown to be quite small—not more than 3 in. Owing to raising of the banks this should be discounted in the future.

Thus it appears that a surge 1·5 ft. higher, coinciding with a freshwater flood, would raise water-levels by about 2·7 ft. above those of 1953. If the extreme, though exceedingly remote, case be considered of the highest possible surge coinciding with a peak spring tide and a freshwater flood, then the resultant water-levels might be expected to be about 6 ft. above 1953.

Also, it should be pointed out that a long-term consideration would need to take into account the relative rise in sea-level, which in south-east England is about 1 ft. a century.

The Waverley Committee[3] was very mindful of the position at London and a special section of its report, submitted in 1954, was devoted to a consideration of the problems of protection. It suggested two alternative schemes as meriting further investigation: a direct raising of the riparian defences, or the construction of a movable barrier across the river. The latter would clearly be a formidable engineering undertaking, involving technical problems of a difficult and unusual nature. It appeared to the Committee that the best site would be in Long Reach between Purfleet and Greenhithe.

In accordance with the Committee's recommendations, a technical panel was constituted in 1954 for the purpose of studying both these proposals. The recently published report, briefly outlined in what follows, is a summary of the findings of the Panel, together with those of the engineering consultants who were afterwards appointed to make a preliminary technical report on the barrier scheme.

Defence Measures

The cost of raising the riparian defences to a height 2–3 ft. above the 1953 water-levels would be in the region of £10 million; to which would have to be added a considerable but unknown sum in respect of compensation to frontagers.

The location and design of a barrier would have to satisfy both flood protection and shipping interests. From each of these points of view the Long Reach site was acknowledged to be the most favourable. With regard to design, however, the stipulations made on navigational grounds were particularly severe. These were that two clear openings of about 500 ft. width should be provided, with a minimum vertical clearance of about 230 ft. Additional smaller waterways would be required for light craft. At all times, except when a dangerous surge was present or imminent, the barrier should be open to the free passage of shipping.

Under the flood warning system, which is at present in operation on the east coast, about 6 hr. notice of a potentially dangerous surge is received and this would enable the barrier to be closed when the water-levels were relatively low. After closure, water-levels would build up independently on either side and the consequent differential pressure head would have to be allowed for in the design of the gates. On the riverine side, the reservoir capacity would have to be sufficient to contain a freshwater flood for the duration of closure. On the estuarine side the gates would have to be of sufficient height to withstand a surge-cum-tide 6 ft. higher than 1953. Also the reflected tidal wave should not cause overspill into important low-lying areas.

With these broad terms of reference, the engineering consultants examined the problem and decided that there were only two types of barrier which could be recommended as being suitable, namely: (*a*) the vertical lifting bridge type; (*b*) the swing bridge type.

The lifting bridge type would consist of three main piers each 75 ft. wide supporting towers 320 ft. high. Between the towers, lifting bridge spans would be suspended and on the lower side these would carry hinged gates. With the barrier open the bridges would be in the fully raised position. When closure was necessary, the bridges would be lowered to just above flood-level and the hinged gates then swung downwards to come to rest in the vertical position against the concrete sill at the bed of the river. A somewhat similar, but much smaller barrier, has recently been constructed on the River Ijssel, Holland. Experience gained in its operation should prove invaluable.

The swing bridge type would have a similar foundation design to that just described, but the three central piers would have a much greater length in the direction of flow. Three lattice girder swing spans would be pivoted on the piers and these would carry the hinged gates in the same manner as in the first type. On closure, the spans would swing on their pivots, meeting in the centre of the two main waterways.

The lifting type would be better for navigation, owing to the shorter piers, whereas the swing bridge type would be easier to maintain. The estimated cost of the swing bridge type is lower—between £13 and £15 million as compared with between £15 and £17 million. Further experiments and investigations would be required before a final choice could be made.

From the flood protection aspect, the barrier scheme is decidedly preferable to the raising of the riparian defences, since the former would provide a standard of protection 6 ft. above 1953 levels whereas the latter could only reasonably be raised by about 3 ft.

The next stage is that consultations between interested parties will take place with the view of establishing the degree of support for the proposals and considering the arrangements for putting them into effect.

Flood Economics

It is often found with flood protection works, and the case of London is no exception, that the capital cost is high and the need only patently demonstrated at infrequent occasions. In these circumstances, there is an understandable tendency for the urgency accorded to a particular scheme to diminish progressively with the time which has elapsed since the last flood. A gamble with fate is tempting when the odds are long, but it is generally advisable to be cognizant of the stakes.

The worthwhileness of a protection scheme may be assessed on an economic basis. This entails a comparison between the cost of protecting against a particular flood, and the cost of the damage which would otherwise result. It is of course necessary to take into account the likely interval of recurrence of the flood, and this may be estimated by statistical methods.

The danger to public safety and the damage which would be associated with various degrees of overspill in London have not been generally made known. It is significant, however, that the Dutch are planning the Delta scheme on the basis of a flood with a 10,000-year recurrence interval. This standard may be compared with the estimated 400-year interval of the 1953 flood.

N. B. Webber

[1] "Technical Possibilities of a Thames Flood Barrier". Pp. 30+3 plates. (Cmnd. 956.) (London: H.M. Stationery Office, 1960.) 3*s.* 6*d.* net.

[2] Allen, F. H., Price, W. A., and Inglis, C. C., *Proc. Inst. Civ. Eng.*, **4**, Pt. 3, 48 (1955).

[3] "Report of the Departmental Committee on Coastal Flooding". (Cmnd. 9165.) (London: H.M. Stationery Office, 1954.)

ARID ZONE PROBLEMS

A GENERAL symposium on the "Problems of the Arid Zones" was held at Unesco Headquarters in Paris during May 11–18. It was attended by more than two hundred delegates, representing twenty scientific disciplines, from thirty-four countries, the latter including all the major arid areas of the world; the U.S.S.R., the United States, France and the United Kingdom were all well represented.

The symposium was opened by Mr. Vittorino Veronese, director-general of Unesco, who warmly welcomed the distinguished delegates from so many countries. He directed attention to the importance of the arid zones, which cover one-third of the Earth's surface, in relation to the need for increasing the food resources of the rapidly increasing world population, which has already reached the 2,000 million mark, and is expected to double itself within the next fifty years. The universal character of the results of research in the arid lands and the importance of employing them to the common good make this research a suitable field for international action, particularly through Unesco, which is charged by its constitution to promote scientific research with the view of improving the living conditions of mankind.

The director-general introduced the president of the symposium, M. P. Piganiol, delegate-general for scientific research of the Government of France, whose responsibilities cover the organization of scientific research in that country; he addressed the delegates on the main problems to be faced by the symposium, the principal object of which was to evaluate the results already achieved and to make recommendations regarding the future course of arid zone research.

The general arrangements for the symposium, which followed the recommendations of the Unesco Advisory Committee for Arid Zone Research at its meeting in Madrid in September 1959, were carried out with great care and efficiency by the Arid Zone Unit of the Unesco staff. Review papers covering the principal scientific disciplines were requested from acknowledged leaders in their particular fields, and the discussions that followed added considerably to the value of the papers. The Proceedings of the symposium, which should be of considerable scientific interest and value, will be published in English and in French by Unesco in its Arid Zone Research Series.

In 1951 Unesco was given the task of promoting research in the arid zones, which for this purpose are taken as including also the semi-arid areas; by an extension of stock raising and the building of great new irrigation schemes in suitable areas, these zones are capable of augmenting considerably world food supplies. This basic research led to such interesting and useful results that in 1957 the activities were raised to the rank of a major project, whereby increased funds were made available for it with special reference to the arid belt extending across northern Africa from Morocco to Egypt and thence through the Middle East to Pakistan and India. Following eight years of activity on the many facets of arid zone research, including three years devoted to the major project, the general symposium has been held with the object of reviewing the results of this research and to suggest new directions of useful activity.

Also, since the major project is due to be terminated at the end of 1962, this review had to be made now in order to provide in good time for the continuation of arid zone research after 1962. The General Conference of Unesco in 1958, in approving the holding of the general symposium, had directed the director-general to submit to it in November, 1960, a report on the past effectiveness, and recommendations for the future course, of the major project, on the basis of the study and recommendations of the symposium.

In order to achieve this purpose, the symposium was divided into four parts.

(1) Critical Appraisal of the State and Perspectives of Knowledge in the Various Scientific Disciplines Involved

For this part of the symposium, review papers were presented in the following fields of science, most of which have formed the subjects of symposia or research reviews organized under the Unesco Arid Zone Programme:

(i) Surface hydrology (including sedimentation)—Dr. W. B. Langbein, U.S. Geological Survey, Washington.

(ii) Geology, geomorphology and ground-water hydrology—Dr. F. Dixey, former director of Overseas Geological Surveys, London.

(iii) Climatology (including hydro-meteorology)—Dr. C. C. Wallen, Swedish Hydrological and Meteorological Service, Stockholm.

(iv) Microclimatology (physical and biological)—Prof. W. R. Van Wyk and Prof. J. de Wilde, Agricultural University, Wageningen.

(v) Soil science (including soil conservation)—Dr. Georges Aubert, Chef du Service des Sols de l'Office de la Recherche Scientifique et Technique Outre-Mer, Paris.

(vi) Salinity problems of plants and soils—Dr. H. E. Hayward and Dr. L. Bernstein, U.S. Salinity Laboratory, Riverside, California.

(vii) Plant physiology—Prof. M. Evanari, Hebrew University, Jerusalem.

(viii) Plant ecology—Prof. G. Lemée, Faculté des Sciences, Paris, and Prof. L. Emberger, Institut de Botanique, Montpellier.

(ix) Human and animal physiology and ecology (including human and animal population problems)—Dr. D. H. K. Lee, Quartermaster Research and Engineering Command, Natick. Development of arid lands and its ecological effect on the insect fauna—Dr. B. P. Uvarov, former director, Anti-Locust Research Centre, London.

(x) Local energy sources—Mr. E. W. Golding, Electrical Research Association, London, and Dr. Tabor, National Physical Laboratory, Jerusalem.

(xi) Saline water conversion—Dr. E. D. Howe, College of Engineering, University of California, Berkeley.

(2) Appraisal of Unesco's Activities in Promoting Research and Training related to Arid Zones

This was supplemented by reports on related activities of international governmental organizations

and by reports from Member States in the major project areas.

Under this heading was presented a comprehensive report by the Secretariat describing Unesco's activities under the major project and the preceding arid zone programme in organizing the symposia and research reviews already referred to, the financial and technical assistance given to a number of research institutes within the arid zone, as in Egypt, Israel, India and Pakistan, the organization of training courses in hydrology, plant ecology, microclimatology, etc., required by the scientific staff of arid lands, and the granting of fellowships in such subjects; the report also underlined the results achieved and the difficulties encountered. The United Nations Water Development Centre, the United Nations Special Agencies, including the Food and Agriculture Organization, the World Health Organization, and the World Meteorological Organization, the international scientific organizations, including the International Union of Geodesy and Geophysics, the International Geographical Union, and the International Commission on Irrigation and Drainage, and the Commission for Technical Co-operation in Africa South of the Sahara, also submitted reports of their activities and plans in relation to the arid zone. Finally, most of the Member States of the region of the major project submitted similar reports.

These various reports demonstrated the close collaboration that exists between Unesco and the Special Agencies, and certain international scientific bodies, in the joint attack on the problems of the arid zones; for example, Unesco co-operated with the Food and Agriculture Organization on a desert locust ecological survey, on an ecological map of the Mediterranean area, and on forest and grazing policies in arid and semi-arid areas, with the World Meteorological Organization on the measurement of solar radiation and on a climatological survey of solar radiation, with both Organizations on an agro-climatological study in arid and semi-arid areas of the Mediterranean region, with the International Association of Scientific Hydrology in certain hydrological and hydrogeological problems, and with the International Commission of Irrigation and Drainage on the prevention of evaporation losses from irrigation systems.

(3) Studies on Selected Problems illustrating Difficulties in Translating Knowledge into Action in Arid Zone Research, Training and Development

Since it had become increasingly clear with widening experience that a considerable gap tends to develop between the accumulating scientific knowledge of the problems of the arid zone and its application in daily life by the pastoral, agricultural and other inhabitants of the lands concerned, papers were called for devoted essentially to the difficulties of translating knowledge into action in certain typical situations; accordingly papers were presented under three main headings as follows:

(i) *Nomadism in relation to grazing resources.* The Sahara and the Saheli—Prof. R. E. Capot-Rey.

Moving of flocks in the Sahelian zone—O. Bremand and J. Pagot (Prohuza).

The Near East Arab countries—Dr. Mohammed Awad, Cairo.

The mountain and plateau areas of South-West Asia– Dr. F. Barth, Norway.

Nomadic pastoralism—Food and Agriculture Organization, Rome.

(ii) *Alternative uses of limited water supplies.* Studies were presented underlining approaches in four distinctive regions as follows:

United States. Water and the arid zone—Dr. L. Leopold, U.S. Geological Survey, Washington.

Algeria. Possibility of using minor water resources —Mr. G. Drouhin, Director de l'Hydraulique et de l'Equipement Rural, Algiers.

United Arabic Republic. Egyptian region—Dr. Youssef Simaika, technical adviser, Ministry of Public Works, Cairo.

U.S.S.R. Basic trends and methods of water control—Prof. A. N. Askoschensky, member of Lenin's Academy of Agricultural Sciences, Moscow. Also, Prof. Gilbert White, University of Chicago, considered these regional aspects in a review paper on alternative uses of limited water supplies.

(iii) *Public awareness and the educational problem.* Under this heading were submitted papers related to certain special problems in arid zones as follows:

Agriculture (Israel)—Prof. D. Weintraub, Hebrew University, Israel.

Irrigation and land use (Pakistan)—Dr. A. G. Ashgar, Pakistan.

Mineral resources (Sahara)—J. Petit, Prohuza, French Research and Information Centre on Human Problems in Arid Zones.

Agriculture: extension work in the Near East—Z. Behravesh, Food and Agriculture Organization.

(4) Study of the Perspectives for Future International and National Action in Arid Zone Research, Training and Development

The discussion at this concluding session of the symposium was based on the previous papers and discussions, and on a paper prepared by Unesco showing the administrative, financial and other considerations to be taken into account in submitting proposals for an extension of Unesco's arid zone research programme.

From this discussion it was clear that the symposium was unanimously of the opinion that the Unesco arid zone research programme should be continued for some years at not less than the present level, and that it should be extended particularly to cover the Latin-American countries; it was considered also that the organization of training courses and fellowships should be expanded. In addition, it was recommended that the Advisory Committee should continue to function on its present lines. Finally, many new projects and lines of research were suggested, including particularly an international study of the artesian basins of northern Africa; the extension of integrated surveys, including surveys relating to geology, geomorphology, water supplies, pedology, plant ecology and microclimate; the study of plant response to environmental factors; soil biology; insect pests and plant diseases; diseases linked with irrigation systems; and human environmental physiology.

The suggestions and comments made at the symposium were examined by the Unesco Advisory Committee on Arid Zone Research in a special review session held immediately afterwards, and they will be taken carefully into account when the Unesco governing bodies come to consider the future of arid zone research. The Advisory Committee met also

during the two days prior to the symposium, and the Sub-Committees on Cartographic Problems in the Arid Zones, and on the Socio-Economic Problems of the Arid Zones, also held meetings at this time.

During the symposium there was an exhibition of maps, photographs and publications illustrating the activities of Unesco, the member States and other bodies; two excellent films were also shown—the Unesco film, "Arid Lands", produced by World Wide Pictures, Ltd., based mainly on scenes and research activities in Pakistan, Israel and Morocco, and a Russian film depicting arid zone development, in respect of irrigation, dry farming and stock raising, in the Karakum and other deserts of the U.S.S.R. Also, a party of delegates visited the phytotron being set up at Gif-sur-Yvette by the Centre National de la Recherche Scientifique; the studies in plant physiology at the phytotron, with special reference to growth under varying conditions of light and temperature, were demonstrated by the director, Prof. P. Chouard.

In respect of the high standard of the papers presented, of the many countries of the arid zone represented, and of the free discussions that followed the papers, the symposium marked an important stage in the study of the arid zones; moreover, it afforded a valuable review of present knowledge and of the scope and nature of future research, and it clearly achieved its objective in presenting, for the consideration of the governing bodies of Unesco, a unanimous and broadly based opinion on the importance of maintaining arid zone research and training at a high level.

Whatever may be the final decision, Unesco's achievements to date will rank high as a contribution to science in making known the problems of the arid zones, and in assisting in their scientific investigation, thereby leading also to the increased economic and social development of these lands. F. DIXEY

SELF-REGULATION IN LIVING SYSTEMS

THE Ottawa symposia on "Self-regulation in Living Systems" organized by Dr. D. K. C. MacDonald of the National Research Council shows signs of becoming an annual series (*Nature*, **184**, 239; 1959, and **183**, 370; 1959). The third meeting was held on March 4, in Montreal, with the Montreal Neurological Institute and McGill University as joint hosts. The attendance exceeded thirty people, representing most medical branches, physics and engineering. The theme was "Tremor", and on this occasion the topics of discussion were introduced by clinicians and illustrated with the willing co-operation of patients. Discussion during the day was general and spirited.

Dr. F. L. MacNaughton (Montreal Neurological Institute) introduced the subject of 'clonus' (alternating contractions and relaxations of muscle). A patient with ankle clonus was introduced and subsequent discussion on the mechanism of oscillation was therefore restricted to this example. The oscillation could be initiated by a sharp application of force to the ball of the foot, and was sustained as long as the force remained. Simultaneous but asynchronous oscillation of both feet could be produced. The oscillation frequency was about 4 c.p.s. and increased only slightly with pressure. The disease had been caused by a spinal tumour pressing on the spinal cord; the tumour had recently been removed and there was some slight improvement in the patient's condition. She was paralysed from the waist down and could not feel the clonus directly. MacNaughton explained that the disease was known to be caused at the spinal cord level, rather than higher in the central nervous system. Ankle clonus was produced mechanically by involuntary contractions of the leg's rear lower muscle (gastrocnemius) followed by relaxation under action of the external force. Clonus was not produced by a coupled oscillation between the rear and front leg muscles, and disappeared if the afferent stretch receptors in the gastrocnemius were cut. Any healthy person can produce clonus, for example, by trying to lift an unliftable weight.

After this discussion Dr. MacDonald (National Research Council) exhibited a simple closed-loop system as an illustration of the instability features discussed above. In this demonstration a galvanometer mirror deflected a light beam so as to follow the physical movement of a photo-cell. Normal stable following was produced by negative feedback at some gain. Sufficiently increased gain, however, drove the light spot into a tremor, as did increase of the controllable time-delay in the circuit.

Dr. Burns (McGill) discussed the physiology of the basic causal loop; that is, muscle-stretch receptor—multiple afferent nerves—spinal cord—multiple motor neurons-muscle. With nerve propagation speed of order 10^2 m./sec. and nerve-length of order 1 m., the propagation time of the nerve in the loop is 20 msec. (2 nerves); other lag-times in the circuit are negligible. This loop delay-time would produce an oscillation of 25 c.p.s. if it were the direct cause of clonus, but this provides poor correlation with the observed 4–10 c.p.s., and of course this closed-loop action is the same in normal healthy voluntary actions.

The situation is complicated by the fact that the components of a multiple-nerve system do not fire simultaneously, but rather in a statistical pattern approaching a Gaussian distribution of frequency, and propagation velocities are also distributed about a mean in the range 70–120 m./sec. Furthermore, the excitability of a nerve follows a time pattern after firing as indicated in Fig. 1.

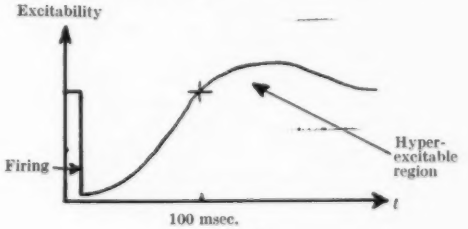

Fig. 1

In discussion, Dr. Burns wondered whether the nerves in clonus might fire almost simultaneously due to hyperexcitability. The observed oscillation frequency corresponds well to a closed-loop oscillation based on the 100-msec. time-delay to hyperexcitability in a nerve after firing.

In the afternoon, Dr. MacNaughton introduced a patient with Parkinson's disease. The particular symptom studied was a tremor of the thumb and forefinger, in the frequency range 3–5 c.p.s. Amplitude increased with concentration, excitement and fatigue, but disappeared during sleep. Application of a heavy weight to the hand only reduced the amplitude. Purposeful action of the hand was quite possible and tremor decreased during a 'slewing' action, but increased, for example, as the hand approached the pen it was going to pick up.

Dr. Blundell (Montreal Neurological Institute) discussed the tremor problem from the point of view of the surgeon, particularly in relation to Parkinson's disease. Surgical possibilities are: (1) To cut the motor nerves; but then no movement is possible. (2) To cut the afferent nerves. This removal of feedback would be justified in extreme cases if it overcame incapacitating tremor. This is true of clonus, but in one known operation on a Parkinsonian case, tremor remained, although at a different amplitude. (3) To cut in the area of the central nervous system. This is the current field of research. Results so far are rather conflicting, and there is insufficient knowledge for confident surgery. Dr. Blundell then detailed the following possibilities as tremor producers: (1) servo-loop oscillations; (2) rhythmic oscillations, for example, by a steady driving mechanism in the brain; (3) hyperexcitability of cells, due to disease.

Dr. Burns also developed the physiology of muscle action somewhat further. Recently a second loop (the 'gamma' loop) has been identified by which 'small' motor neurons are fired from the spinal cord to contract the fibre which is measured by the length receptor. In addition, the afferent nerves from the stretch receptors communicate with the central nervous system. In turn the central nervous system communicates with both the 'big' and 'small' motor neurons. Several more loops are thus added, and much remains to be learned of the combined control action.

Dr. Jasper (University of Montreal) described extensive experimental measurements on tremor, being carried out at the University of Montreal, using micro-electrodes. Frequency measurements of the action potential of muscles in clonus and Parkinson's disease look exactly alike. On the other hand, the cortical phenomena seem different. Some 15–20 per cent of the cortex cells seem to show activity correlated with tremor, but not enough is yet known. In monkeys, tremor has been produced by a small cut in the brain in the appropriate area; a 'large' cut can then remove the tremor.

Finally, Dr. J. A. Tanner (National Research Council) reported the work being done by Massachusetts Institute of Technology and Yale University on measuring the impedance of the wrist and finger extremities when subjected to sinusoidal or stochastic vibrations. The impedance falls with frequency as might be expected for an inertial load, except that in healthy people there are resonant peaks in the 7 and 17 c.p.s. regions. These are as yet unexplained. In patients with tremor the major resonance is due to the tremor, but at a different frequency than the tremor itself, lying between the 7–17 c.p.s. peaks. This overshadows the other resonances, naturally enough.

A spirited discussion followed concerning the relative usefulness of the 'black box' technique as illustrated by the impedance measurements just described, and the classic analysis-techniques in which individual elements are isolated and their characteristics learned before they are combined together. Everyone agreed that the latter method is ideal if it can be used. Opinion was divided as to whether the 'black box' techniques could be useful, since the 'black box' may often be altogether too complex. I myself feel that both approaches are useful and must be pursued in parallel. This in fact is done of necessity in both engineering and medicine at least.

J. H. Milsum

SCHIZOPHRENIA AND LOW-GRADE MENTAL DEFICIENCY IN SWEDEN

A CLINICAL and genetico-statistical analysis of schizophrenia and low-grade mental deficiency of a large rural population of 25,000 people in Sweden indicated that altogether 1,790 individuals belonging to 231 families were suffering from schizophrenia, and 1,541 individuals belonging to 215 families were low-grade mental defectives*.

Of the cases of schizophrenia, 50 per cent were classified as hebephrenic, 33 per cent as catatonic, 10 per cent as paranoic and 7 per cent as atypical. 70 per cent of the cases had symptoms generally described as catatonic, but only 20 per cent had them in connexion with the onset of the psychosis.

The mean age at onset of schizophrenia among females, 32 years, is significantly higher than that, 28 years, among males. The psychosis had an acute onset in approximately 40 per cent of the cases and a periodical course in many cases, there being no sex difference. There is thus a positive relationship between acute onset of schizophrenia and periodical course of the psychosis.

There was a statistically significant association between schizophrenia and mental deficiency. Such an association has not been statistically established previously. The morbidity-rate for mental deficiency —including high-grade defectives—among the schizophrenic propositi is $10{\cdot}5 \pm 1{\cdot}9$ per cent as against a risk of 3 per cent estimated for the general population. The morbidity-rate for mental deficiency among the sibs of propositi was no higher than the

* A Clinical and Genetico-Statistical Study of Schizophrenia and Low-Grade Mental Deficiency in a Large Swedish Rural Population. By Bertil Hallgren and Torsten Sjögren. (*Acta Psychiatrica et Neurologica Scandinavica*, Supplementum 140, Volumen 35, 1959.) Pp. 65. (Copenhagen: Ejnar Munksgaard, 1959.)

risk in the general population of the area studied, nor was the rate of schizophrenia among the sibs of propositi affected with low-grade mental deficiency increased.

The genetico-statistical analysis confirms the conclusions of previous investigations that specific genetic factors are of importance for the manifestation of schizophrenia. The morbidity-rate for schizophrenia as well as that for non-psychotic mental abnormalities among the sibs of propositi was significantly higher in the families where one of the parents was affected with psychosis or non-psychotic mental abnormality (mainly severe personality deviations) than in those where both parents were unaffected.

Of the mental defectives 88 per cent belonged to the group of uncomplicated, undifferentiated mental deficiency. In 4·1 per cent of the cases the mental defect was combined with epilepsy, in 3·3 per cent with deaf-mutism and in 2·6 per cent with spastic paresis. These figures are considerably higher than corresponding frequencies of epilepsy, deaf mutism and spastic paresis in the general population.

The genetico-statistical analysis confirms the findings of previous investigations that specific genetic factors are of importance for the manifestation of undifferentiated low-grade mental deficiency. In the unclassified material, the morbidity-rate for the low-grade mental deficiency among the sibs of propositi with uncomplicated undifferentiated mental deficiency is $8{\cdot}4 \pm 0{\cdot}9$ per cent. This rate is significantly higher than the corresponding risk, 0·9 per cent in the general population. The rate among brothers, $11{\cdot}3 \pm 1{\cdot}5$ per cent, is significantly higher than that among sisters, $5{\cdot}6 \pm 1{\cdot}1$ per cent.

RADIOACTIVE FALL-OUT IN GHANA

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ROUTINE radioactive survey measurements were started in Ghana in October 1959, after the announcement of French atomic testing plans at Reggan in the northern Sahara. The measurements were extended in January 1960, and the first atomic explosion at Reggan was on February 13. It gave a peculiarly simple variation of radioactive fall-out in Ghana, as it was a single isolated test, after all other fall-out levels had fallen considerably following the cessation of atom bomb tests in 1958. The unexpected relatively large increase in radioactivity of samples of dust, crops, soil and water is summarized; most of the measurements were by gross β- or γ-counting, and no chemical separation has yet been made.

Radioactivity-levels were very low in Ghana before February 13; there is little natural uranium or thorium in the country, and because of Ghana's position near the equator, world-wide fall-out from earlier atomic tests had produced only very slight contamination. Daily measurements since January of activity in air-borne dust, deposited dust, and milk have been made at two laboratories, and the main results are shown in the two graphs. Tamale is in the Northern Region of Ghana, 1,000 miles south of Reggan, and the Accra laboratory is at Legon, 8 miles from the coast and 1,400 miles south of Reggan.

The graphs show the daily measurements of radioactivity in air-borne dust per cu. m., and in deposited dust per sq. m. per day. Air-borne dust is collected by filtration under forced flow, using the method developed by the Radiation Protection Division of the Canadian Department of Health and Welfare; an air pump is fitted with a glass-fibre filter paper and with the average loading of dust has a capacity of about 720 m.³ a day. Each pump and filter is in a Stevenson screen, that at Tamale being 3 ft. above ground-level, that at Accra being on a flat roof 21 ft. above ground-level. Deposited dust was swept up daily from a measured area of flat concrete roof, 21 ft. above ground-level at both Tamale and Accra; during peak periods the same area was swept each day until any remaining activity was negligible.

The contamination reaching Ghana was dust-borne, and from the graphs the bulk of the contamination appears to arrive between the third and tenth days after the explosion. Thereafter, the daily arrival of contamination is seen to fall off slowly; some of the delayed arrival may be 'secondary' in origin, as dust was blowing up freely from all soil and sand surfaces in Ghana and in the Sahara at this time, due to the extremely dry weather conditions. The fall-off in daily arrival of contamination is, however, more rapid than the radioactive decay of mixed fission products, indicating that the total radioactivity carried by this 'secondary' dust is very much less than in the original bulk of contaminated dust direct from Reggan.

The decay of each sample is complicated. All air filters collect natural radium and thorium daughter products as well as fall-out radioactivity. The radium and thorium daughter products decay rapidly, and their effective μμc./m.³ content is shown on the graph up to February 16. After this date, the fall-out alone is shown; from repeated counts the contribution of the longer-lived fall-out can be separated from the rapid decay of the radium and thorium daughter products. On the other hand, for deposited dust the total radioactivity content is shown in all cases. Each sample of fall-out has been stored and counted repeatedly to establish its own decay scheme. Apart from some of the 'peak' samples which initially decayed more rapidly, all samples gave a rate of decay fitting closely to the curve:

$$I_t = I_0 t^{-1\cdot3} \text{ (from } t = 4 \text{ days onwards)}$$

Dust particles varied in size, and it seemed likely that the larger particles were more local in origin than the smaller ones. Specimens of collected dust were therefore passed through a 50-μ sieve, and it was found that the specific activity of the transmitted

* Technical adviser loaned to Ghana by Canadian Government.

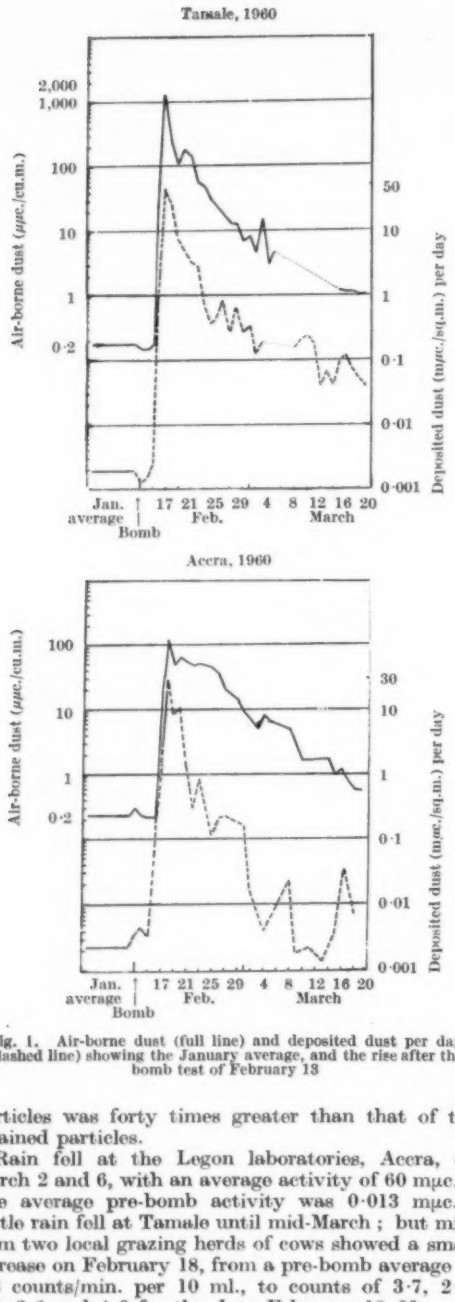

Fig. 1. Air-borne dust (full line) and deposited dust per day (dashed line) showing the January average, and the rise after the bomb test of February 13

particles was forty times greater than that of the retained particles.

Rain fell at the Legon laboratories, Accra, on March 2 and 6, with an average activity of 60 mμc./l. The average pre-bomb activity was 0·013 mμc./l. Little rain fell at Tamale until mid-March; but milk from two local grazing herds of cows showed a small increase on February 18, from a pre-bomb average of 1·8 counts/min. per 10 ml., to counts of 3·7, 2·8, 2·6, 3·6 and 4·0 for the days February 18–22.

From the other thirty stations in Ghana, samples of dust deposited over weekly periods, of exposed leaves and top soil, were sent to the main laboratory at Legon for β and γ analysis. In addition, transistorized equipment was taken by 'Landrover' on a survey of northern Ghana. The results give a simple area and time variation which is consistent with the detailed analyses from the Tamale and Legon laboratories.

The γ counting of top soil probably gives the best measure of cumulative fall-out, but β- and γ-counting of exposed leaves and of dust swept from measured areas of flat concrete surface provides useful confirmatory figures. The average of all measurements for the cumulative fall-out up to the three dates shown is given below, in units of mμc./m.². The high, medium and low counts correlate well with the 'north' (nine stations), 'central' (thirteen stations) and 'south' (eight stations) of Ghana (Table 1).

Table 1

	Pre-bomb average	Cumulative to Feb. 20	Cumulative to Feb. 27	Cumulative to March 18
North	11	126	55	13
Central	13	42	16	5
South	12	17	6	3

The first column refers to soil samples only, for a 2-in. deep section of top soil; these pre-bomb figures, or equivalent 'deep soil' samples after the test, have been subtracted from top soil counts to give the cumulative fall-out figures of the last three columns. Pre-bomb leaf measurements gave negligible counts even with a Philips-type low-background counter; pre-bomb dust figures are very small, and have been subtracted in the graphs and table above. The separate station figures on which the averages in Table 1 are based vary considerably; the highest level found in Ghana was 4·6 times the average 'north' figure.

On leaf samples of February 20, most of the radioactivity could be washed off, and so was attributed to surface dust; in later leaf samples more of the contamination was 'fixed' in the leaves.

The amount of dust radioactivity makes γ-spectroscopy very easy, even with a single-channel pulse analyser. γ-spectra taken from specimens of different ages after February 13 were found to be typical of mixed fission products of those ages, and these results were confirmed and extended by courtesy of two health physics laboratories in the United Kingdom.

The increased radioactivity-levels described above are much higher than those generally predicted for Ghana before the February 13 test at Reggan. Those familiar with local conditions had, however, anticipated that direct fall-out was a possibility, on account of the wind circulation which occurs for the period December–March, and its occasional unusual variations. Detailed wind trajectories from data taken during February 13–18 agree well with the observed times of arrival of the main increases of radioactivity, both in Ghana and Nigeria. The röntgen doses from these increases, however, are still low. Calculations from the mμc./m.² figures, together with a few direct dose-rate readings, assuming a $t^{-1\cdot2}$ decay, indicate a total gonad dose for the maximum 'north' fall-out of less than 1 millirad for the year from the first French bomb test. It is considered by many authorities that an additional dose to a whole population of 500 millirads is acceptable genetically.

We wish to thank the Ministry of Defence of Ghana for financing the work and for permission to publish these results, and to acknowledge the valuable assistance of the professor of physics, members of his Department, and the Director of Meteorological Services in Ghana.

RADIOACTIVE LABELLING OF LEPIDOPTEROUS LARVÆ: A METHOD OF ESTIMATING LATE LARVAL AND PUPAL MORTALITY IN THE WILD

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AND

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THE special advantages of marking insects by means of radioactive tracers have been explained in a previous communication by one of us[1]. It was pointed out that the technique allows even holometabolous species to be detected through successive instars and between stages in metamorphosis. A method was described for calculating pupal mortality using individuals marked as larvæ. Phosphorus-32 was employed for species with a rapid metamorphosis (*Locusta migratoria* L. and *L. pardalina* Walk.), and sulphur-35 for those with a longer life-history (*Panaxia dominula* L.)[2]. This work was conducted under laboratory conditions, and no field releases were undertaken at the time. The marking of adults by feeding a radioactive tracer to the larvæ has been carried out on a number of occasions[3–5], but the unique advantages of this method of recording individuals in studies of population dynamics have not so far been fully utilized. We present here the results of two estimations of late larval and pupal mortality under natural conditions in colonies of the moth *Panaxia dominula* (L.).

I. 1953 (H. B. D. Kettlewell)

The colony of *P. dominula* at Sheepstead Hurst, Berkshire, was studied for some years by Dr. P. M. Sheppard[6]. He estimated the total size of the adult population in each season using Fisher's multiple recapture method[7]. In 1953 a sample of larvæ was taken from this colony and fed on deadnettle (*Lamium* spp.) which had been grown in water culture containing sulphur-35. 1,227 larvæ were returned to the colony, each giving 20 counts per minute or more above the background when scanned under a Geiger counter. Larvæ with counts as low as this can be used because the earlier work had shown that the recorded activity in the imagines is always two to six times greater than that in the same individual when scored as a larva more than two months earlier. Sulphur is present in the wings of the adults, but in the larvæ it is principally internal, and the low larval count is due to the low penetrating power of the isotope.

The larvæ were extremely abundant in 1953, and in view of the heavy predation by cuckoos (they are probably the main visual predators of the species), it was decided to shoot one some days after the release. The remains of about 25 *P. dominula* larvæ were present in the gizzard, but none gave radioactive counts, nor did the intestine, liver, heart or any other part of the cuckoo. I did, however, note that there was a complete absence of larval hairs and skins in the small intestine, which suggests that the cuckoos regurgitate the larval roughage, probably in the form of small pellets.

In July 1953 the total adult population in the colony was estimated by Sheppard[6] to be between 20,000 and 26,000. In the course of the sampling from which this estimate was obtained, each captured insect was taken to the laboratory and scanned before being released again into the colony. The labelled insects were clearly distinguishable from non-radioactive ones, the lowest count recorded being 76 c.p.m. above background. The results are given in Table 1.

Table 1. Numbers of Radioactive Individuals in Random Samples of Imagines

Date	Number of radioactive insects	Total sample
1.7.53	—	80
2.7.53	—	99
3.7.53	—	125
4.7.53	—	207
5.7.53	—	127
6.7.53	2	119
7.7.53	4	229
8.7.53	5	160
9.7.53	3	285
11.7.53	0	164
12.7.53	0	251
13.7.53	1	259
14.7.53	0	276
15.7.53	2	141
16.7.53	0	316
17.7.53	0	211
18.7.53	0	180
19.7.53	1	210
21.7.53	0	197
22.7.53	0	143
23.7.53	0	148
24.7.53	0	111
	18	3,400 + 638 = 4,038

$$\text{Total larval population} = \frac{\text{radioactive larvæ released} \times \text{total imagines caught}}{\text{radioactive imagines caught}}$$

The imagines were not scanned on the first five days of collection; but using the ratio of the number of labelled insects to the total number in the sample from which they are recorded as an estimate of the frequency of radioactive individuals in the population, the mean number of larvæ is calculated to be 231,767. The data suggest that marked individuals emerged slightly in advance of the rest of the population, however, so they may have been present at a higher frequency in the first few days. This is possibly because they were kept at a slightly higher temperature than the rest of the population during the 48-hr. feeding period. Inspection of the scatter of their distribution in the later samples suggests that 5 or 6 may have been present, and to recalculate the larval population size the figures 4 and 7 have been used. Assuming the number of marked insects in the total sample of 4,038 to lie between 25 and 22, the mean number of larvæ is estimated to be between 198,185 and 225,210. With a total adult population of approximately 23,000 this gives an estimate of mortality over the intervening period of 88–90 per cent.

It was apparent that the marked larvæ could be recognized clearly when recaptured as adults; and no difference was observed between the viability of radioactive and non-radioactive controls. It was therefore decided to employ the same technique again to assess late pre-adult mortality, this time in a very small colony which had thrived for some years in a

wild state in the vicinity of Oxford, following its original introduction from a laboratory stock.

2. 1959 (L. M. Cook)

The larvæ were marked in the same way as before. When nearly full grown they were fed on radioactive *Lamium* for 24 hr., care being taken to ensure that the temperature was as near that prevailing in the colony as possible. 165 larvæ were returned to the population immediately after feeding. At the same time four containers were set up with mixed batches of radioactive and non-radioactive larvæ as controls. The moths from them were scored as they emerged, and despite the fact that there was heavy over-all mortality during pupation there is no evidence that it is distributed differentially between active and non-active larvæ (Table 2). The marked moths showed no tendency to emerge earlier than those which were not radioactive.

Table 2. Survival of Controls

	Radioactive	Non-radioactive
Total number of larvæ used	30	30
Number of adults which emerged	4 4 3 4	7 3 8 1
Total adult emergence	15	19

$\chi^2_{(1)} = 0{\cdot}27$, $P > 0{\cdot}5$

Because of the small size of the colony environmental conditions in it were relatively uniform and emergence of adults took place over a very short period of time. A close watch was kept from the beginning of June onwards, and sampling was carried out every day throughout the season. As the moths in the colony emerged they were captured, scanned, marked with a spot of cellulose paint (receiving a distinct mark each time they were caught), and then released. The larval population size has been calculated from the single capture-recapture equation using Bailey's correction[8] and the adult population size by Fisher's method[7]. A summary of the data is given in Table 3. The mean number of larvæ present when the labelled sample was released is estimated as 1,210, and the mean number of adults as 77. The mean value for the mortality over the period between the two estimates is 94 per cent.

The estimation in two different colonies at different times suggests figures for late larval and pupal mortality which are between 85 and 95 per cent. The adults lay about 200 eggs, or approximately 100 per individual. The population at Sheepstead Hurst comprised 6,000–8,000 individuals in 1952 (ref. 9), so that

Table 3. Population Data for 1959

Days from first release	June 21	22	23	24	25	26	27	28	29	30	July 1	2	3
1		3	8	5	3	2	1	1	2	2	4	4	3
2			2	2	3	2	3	0	1	2	3	4	0
3				0	1	2	0	1	2	1	2	2	1
4					0	2	0	0	1	0	0	1	0
5						1	0	0	0	1	1	1	0
6							0	0	0	0	1	0	0
7								0	0	0	0	1	0
8									0	0	0	1	1
9										0	0	0	1
Captures	5	11	13	7	8	9	4	3	6	6	9	7	3
Releases	4	11	13	7	8	9	4	3	6	6	7	6	3
Radioactive	1	1	1	0	0	1	0	0	0	1	0	0	0
Estimated daily adult population size	15	18	21	23	21	22	27	14	15	12	8	8	

Estimated mean adult survival per day 62·4 per cent
Number of tagged larvæ released 165
Total number of moths captured 43
Number of radioactive moths captured 5
Estimated seasonal adult population size 77

the number of larvæ which remained of the 1952–53 generation at the time when they were sampled was only about one-quarter of the total number of eggs produced. Thus, there is heavy mortality in the late stages of development after an appreciable drop in numbers has already taken place. The implications of this situation will be discussed elsewhere. The work presented here demonstrates for the first time that estimates can be made in wild populations, using a radioactive labelling technique, which are of sufficient accuracy to stand as the basis for such a discussion. The method is capable of very wide application to studies of natural populations of insects.

We wish to thank Prof. G. E. Blackman for the use of facilities in the Department of Agriculture. We are very grateful to Dr. R. P. Martin and members of the staff for the help they gave us throughout the course of the work, to Dr. A. J. Cain, Dr. E. B. Ford and Dr. P. M. Sheppard, who read and criticized the paper in manuscript, and to Drs. N. T. J. Bailey, Dennis Chitty and P. H. Leslie, who gave us helpful advice on statistical matters. One of us (L. M. C.) received support from a Nature Conservancy Research Studentship, for which grateful acknowledgment is made.

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ZINC CONTENT OF ERYTHROCYTES AND LEUCOCYTES OF BLOOD OF NORMAL AND LEUKÆMIC SUBJECTS

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MANY studies have been made on the significance of zinc in the eye, pancreas, the male genital tract, and other tissues of the animal body[1,2]. Since the recognition that carbonic anhydrase is a zinc enzyme, with the metal as an integral part of the enzyme molecule[3,4], considerable progress has been made, largely by Vallee and his colleagues[5], in characterizing the alcohol dehydrogenases, glutamic acid dehydrogenase, lactic dehydrogenase, and carboxypeptidase, as zinc metalloenzymes. Also, zinc ions

increase the activity of many enzymes, and there appears to be little doubt that this metal has important biological functions relating to cellular oxidation and possibly other aspects of metabolism.

Zinc is present in blood plasma, in which the metal is largely bound to the β-globulins (ref. 6 and unpublished work by us), and in erythrocytes and leucocytes, and although the last-named cells contain only about 3 per cent of the whole-blood zinc[7], the individual leucocyte is relatively rich in this metal, and "probably contains more zinc than does any other cell in the body"[8]. A protein which contains 0·3 per cent of zinc and which accounts for about 80 per cent of the leucocytic zinc has been isolated from normal human leucocytes[8,9], but as yet there is no information about the function of this protein. In work on the zinc content of the blood of five individuals suffering from myeloid leukæmia and three from lymphatic leukæmia, Vallee and his colleagues found that the zinc contents of the leukæmic leucocytes (expressed as μgm. zinc/10^6 cells) were exceptionally low, ranging from 10 to 40 per cent of the normal values, and they suggested[10] that "one characteristic of the blood dyscrasias known as leukæmia is an inability of the leucocytes to attain a normal zinc content". Wolff[11] has also obtained relatively low values for the serum zinc and the leucocyte zinc of leukæmic patients.

During recent years we have studied the uptake of zinc by normal and tumour tissues of mice, and we have measured the zinc content of the blood cells of normal subjects and individuals suffering from various types of leukæmia. The determination of the zinc in human leucocytes presents many problems. It is necessary to prepare leucocyte suspensions which are practically free from erythrocytes, and erythrocytes free from leucocytes, and an ultra-micro method of assay for zinc is required. For the separation of leucocytes, we have found dextran the most satisfactory substance to add to the blood to increase the rate of sedimentation of erythrocytes, as advocated by Wildy and Ridley[12]. We have estimated the amount of nitrogen in small samples of leucocytes or erythrocytes by Russell's colorimetric phenol–hypochlorite method[13]. For the zinc determinations, we developed a method of neutron activation analysis[14] which allows duplicate zinc determinations to be made on two or three drops of blood, or the leucocytes separated from 4 or 5 ml. or the red cells from about 0·2 ml. of human blood. The leucocyte samples used for each zinc determination contained 10^7–10^8 leucocytes and about 0·2–0·6 μgm. zinc.

We have made determinations on blood samples from 27 normal subjects and 22 leukæmic patients (15 subjects with chronic lymphatic leukæmia and 7 with chronic myeloid leukæmia), and we have found that the leukæmic leucocytes contained much less zinc (a mean value of 7·7 μgm. (*S.E.*, ± 1·3) of zinc, per 10^9 leucocytes) than did the normal leucocytes, the latter showing a mean zinc content of 14·2 ± 2·1 μgm. per 10^9 leucocytes. This difference between the leukæmic and normal leucocytes is statistically highly significant ($P = 0·02$).

Since leucocytes show considerable variation in size, measurement of the average zinc content per cell may not give the most satisfactory values for comparing the zinc contents of normal and pathological bloods, and we decided to calculate, in addition, the amount of zinc in the red and white cells in terms of μgm. zinc per mgm. of total nitrogen, in order to have a measure of the zinc/protein ratio. With these ratios also, the leukæmic leucocytes showed a very much lower zinc content than did normal leucocytes. The mean values (as μgm. zinc./mgm. total nitrogen) being 0·91 (± 0·08) and 1·97 (± 0·37) for the leukæmic and normal leucocytes respectively. Statistical analysis showed that this difference is highly significant (P between 0·01 and 0·02).

The amount of zinc in the erythrocytes shows a difference in the opposite direction, with the leukæmic erythrocytes giving a mean value of 1·13 (± 0·06) μgm. of zinc per 10^9 cells as compared with 0·96 (± 0·03) for the normal erythrocytes. The corresponding values for the erythrocyte zinc calculated as μgm. zinc per mgm. nitrogen were 0·26 ± 0·01 and 0·21 ± 0·01 for the leukæmic and normal bloods respectively. Statistically, this difference is highly significant (P between 0·02 and 0·05 for the zinc contents measured on a cellular basis, and between 0·001 and 0·01 for the ratios calculated on a nitrogen basis).

The whole-blood samples showed no significant difference between the values for normal and leukæmic subjects, and the relatively low zinc contents of the leucocytes, and the higher zinc content of the erythrocytes, in leukæmic blood as compared with normal human blood, did not appear to be related in any way to abnormally low or high levels of total blood zinc.

The relatively low zinc content of leukæmic leucocytes is of special interest to us at present, and we are making further investigations of this phenomenon. It is possible that the difference is due simply to the relative immaturity of the leukæmic leucocytes, and we are at present studying the zinc content of leucocytes associated with other types of leucocytosis. On the other hand, there is the possibility, as has been postulated by others, that the synthetic processes concerned with the formation of a zinc-protein or some other zinc compound associated with leucocytes, may be deficient in the leukæmic subject. In this connexion, it may be significant that our total nitrogen determinations have shown no significant difference between the amount of nitrogen (and presumably the amount of protein) present in the leukæmic leucocytes and that in normal leucocytes. A full account of these investigations will be published elsewhere.

This work was carried out with the aid of grants from the British Empire Cancer Campaign, and we are also indebted to Dr. T. E. Banks, of the Physics Department of this College, for continued valuable help with the maintenance of our equipment used for radioactivity measurements.

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SERUM ALBUMIN CONCENTRATION IN ANALBUMINÆMIA AND ITS IMMUNOLOGICAL SIGNIFICANCE

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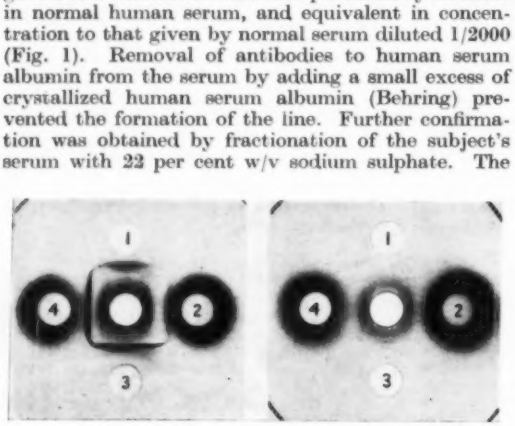
BENNHOLD, Peters and Roth[1] recently described a brother and sister whose sera contained no albumin detectable by electrophoresis. If these persons completely lack human serum albumin, and their last contact with it resulted from transplacental transfer from their mother some 30–35 years ago, it might have been expected that they would treat human serum albumin as a foreign protein and react to transfusion by developing antibodies. In fact, extensive investigations[2] have shown that one of the subjects, who received repeated transfusions of human serum albumin, not only showed no signs of the increased elimination-rate which would have been expected had she formed antibodies, but actually catabolized transfused human serum albumin at about half the rate of normal persons. This raises the question whether albumin might have been present in the plasma in trace amounts even before transfusion, or whether the failure to develop antibodies was due to long persistence of immunological tolerance. The presence of traces of human serum albumin was therefore investigated by other techniques.

Through the kindness of Dr. Kallee a sample of serum was obtained, which was taken from the brother (Karl Br.) before any transfusions had been given. Using a rabbit antiserum specific for human serum albumin, and employing the quantitative precipitin technique, the serum was found to contain a substance reacting immunologically as human serum albumin in concentration 1·6 mgm./100 ml. The identity of this material with human serum albumin was confirmed by the agar-gel diffusion technique, in which the subject's undiluted serum gave a line continuous with that produced by albumin in normal human serum, and equivalent in concentration to that given by normal serum diluted 1/2000 (Fig. 1). Removal of antibodies to human serum albumin from the serum by adding a small excess of crystallized human serum albumin (Behring) prevented the formation of the line. Further confirmation was obtained by fractionation of the subject's serum with 22 per cent w/v sodium sulphate. The supernatant, after concentration by pressure dialysis to 1/3 the original volume, was subjected to paper electrophoresis. Most of the protein was α- and β-globulin, but there was a very faint trace of material with the electrophoretic mobility of human serum albumin.



Unabsorbed Absorbed

Fig. 1. Agar-gel diffusion patterns with rabbit antiserum, before and after removing specific anti-human serum albumin by addition of a small excess of authentic human serum albumin
1, normal human serum 1/1,000; 2, 'analbuminæmic' serum 1/1; 3, normal human serum 1/100; 4, 'analbuminæmic' serum 1/1 containing normal human serum 1/100

Lohss and Kallee[3] have reported that 'analbuminæmic' serum may contain material behaving serologically as serum albumin, but differing from authentic serum albumin in its behaviour after extraction with a trichloroacetic acid-acetone mixture. To decide whether authentic serum albumin was present in the serum under study, the general method used by Lohss and Kallee was modified and extended. The proteins in the serum fraction where albumin might be present were radio-iodinated; they were then precipitated with anti-human serum albumin in the presence of unlabelled carrier human serum albumin; the antigen–antibody precipitate was dissociated with trichloro-acetic acid–ethanol; and the protein so obtained was subjected to electrophoresis in starch gel.

The 22 per cent w/v sodium sulphate supernatant from 1·85 ml. serum was iodinated with iodine-131 by the iodine chloride method of McFarlane[4], after preoxidation of any free —SH groups with non-radioactive iodine. An authentic sample of crystallized human serum albumin was iodinated in the same way for use in parallel control tests. Although the preparation from the 'analbuminæmic' serum contained 23 mgm. protein, less than 0·1 mgm. was expected to be albumin. In order to diminish losses due to adsorption, 2 mgm. of unlabelled carrier human serum albumin was added to the labelled 'analbuminæmic' material and to 0·1 mgm. of the control human serum albumin labelled with iodine-131. The albumin in each was precipitated with 26 mgm. rabbit anti-human serum albumin in the presence of 5 mgm. potassium iodine. As is shown in Table 1, the precipitate contained only 1·1 per cent of the radioactive proteins in the test material. Even this could be partly due to co-precipitation of a part of the other labelled proteins present.

After washing the test and control precipitates twice with 0·9 per cent sodium chloride at 2°, they were stirred with 6 ml. 1 per cent w/v trichloracetic acid in 96 per cent v/v ethanol at 0°, to extract the albumin. After 2 hr. the residual precipitate was spun down at 0°, and the supernatant fluid was treated with 2 volumes of cold dry ether to precipitate the extracted protein. The recovered protein was dissolved in 1 ml. water at 0°. In this way 75 per cent of the radioactivity was recovered from the antigen–antibody precipitate prepared with authentic human serum albumin, but only 19 per cent from that prepared with the 'analbuminæmic' material. Since the bulk of the precipitate in each case was due to unlabelled carrier human serum albumin, and each sample was subjected to identical procedures, the low recovery of radioactivity from the 'analbuminæmic' material must have been due to the presence of

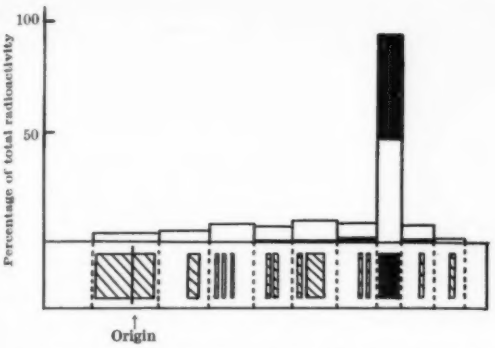


Fig. 2. Distribution of radicactivity after electrophoresis in starch gel of material recovered from analbuminæmic serum and from authentic human serum albumin. The abscissa is a diagrammatic representation of the stained gel, illustrating the position of the cuts
□ = radioactivity in analbuminæmic material; ■ = radioactivity in authentic human serum albumin

labelled contaminants other than albumin in the precipitate.

In order to identify the recovered labelled materials definitely as human serum albumin, 0·1 ml. of unlabelled human serum was added to each, the solutions were concentrated 5–10-fold by dialysis against 'Carbowax' in the cold, and 50 µl. of each was then subjected to electrophoresis in starch gel, according to Smithies[5]. The gels were fixed and stained; the albumin had travelled 10–11 cm. from the origin and was well separated from pre- and post-albumins. The gel was photographed, and then cut into segments corresponding to each protein peak. Radioactivity in each segment was measured in a well-type scintillation counter, care being taken to ensure that conditions of counting were similar. The distribution of radioactivity along the gels is shown in Fig. 2. Whereas 94 per cent of the authentic radioactive human serum albumin was recovered in the albumin band, only 47 per cent of the radioactive protein recovered from the 'analbuminæmic' serum was located in this position, the remainder being distributed throughout the serum proteins.

It is not certain whether the non-albumin radioactivity was associated with denatured material or with traces of labelled globulins which had survived intact the earlier stages of purification, and which would not have been present in the authentic human serum albumin.

When compared with the authentic human serum albumin labelled with iodine-131, only 0·098 per cent of the original iodinated protein in the 22 per cent sodium sulphate supernatant behaved as human serum albumin throughout the successive stages of precipitation with anti-human serum albumin, extraction in trichloracetic-acid ethanol (TCA), and starch gel electrophoresis (Table 1). On the assumption that all the proteins in the 22 per cent sodium sulphate supernatant were iodinated to the same extent, this would imply that the original serum contained 1·23 mgm. authentic human serum albumin/100 ml.—a value quite close to the 1·6 mgm./100 ml. obtained by immunochemical methods. It is not clear why these results differ from those of Lohss and Kallee[3], but the explanation may lie in pre-oxidation of —SH groups before iodination with iodine-131 or in the use of carrier human serum albumin. The results certainly underline their warning that no single technique should be relied on to identify and measure unequivocally a material constituting so small a proportion of a mixture, unless it possesses some readily identifiable specific property such as enzyme activity.

Table 1

Experimental stages	Per cent of original radioactivity recovered	
	HSA	'Albumin' fraction of serum
Precipitated with antibody	99	1·1
Extracted with TCA-ethanol and re-precipitated with ether	75	0·208
Present in albumin peak after starch gel electrophoresis	70·5	0·098

The evidence seems sufficient, however, to permit the conclusion that traces of human serum albumin were present, and that the failure of these subjects to develop antibodies in response to albumin administration does not require postulation of prolonged persistence of a state of immunological tolerance. Furthermore, it seems possible that 'analbuminæmia' may resemble 'agammaglobulinæmia' in being a condition in which there is a very great, rather than an absolute, deficiency of the particular plasma protein. This work was made on serum from a single subject, and it is clearly desirable—though impossible in this instance—to examine by similar techniques the sera from other such subjects before any transfusions have been given.

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ACTION OF SOME SURFACE-ACTIVE COMPOUNDS ON THE GASTRO-INTESTINAL MUCOSA

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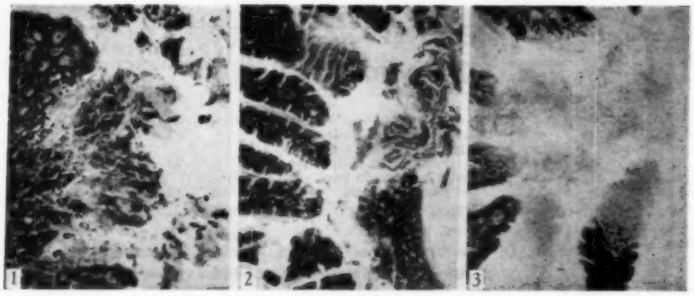
In a previous article[1], the actions of trimethylhexadecylammonium stearate (cetyltrimethylammonium stearate) on the gastro-intestinal mucosa were described. These actions included: (1) damage to gastro-duodeno-jejunal mucosa after large oral and parenteral doses; (2) loss of weight, presumed to be due to functional inhibition of the gastro-intestinal mucosa, after smaller oral doses; and (3) occasional hypertrophy of the gastro-duodeno-jejunal mucosa after prolonged administration of doses that are just



Figs. 1–3. Damage with hæmorrhage in gastric and intestinal mucosa of mouse 16 hr. after a subcutaneous injection of 0·1 gm. cetrimide per kgm. body-weight. (× 86) (1) Pyloric mucosa. (2) and (3) Intestinal mucosa. Note dense altered hæmoglobin pigment at tips of villi in (2)

too small to cause loss of weight. In a preliminary investigation of the mode of action, a number of related compounds have been studied and an attempt made to relate structure and activity.

Trimethylhexadecylammonium stearate is a cationic surface-active quaternary ammonium compound practically insoluble in water. The present investigation includes the study of (1) sodium stearate and cetyltrimethylammonium bromide or cetrimide, two compounds which represent the acidic and basic parts of the molecule; (2) domiphen bromide, sodium lauryl sulphate, sorbitan monostearate ('Span 60') and polyoxyethylene sorbitan mono-oleate ('Tween 80'), of which the first two are cationic and anionic and the last two non-ionic surfactants; and (3) tetraethylammonium bromide and hexamethonium chloride, two simple quaternary ammonium compounds. In preliminary screening tests, these compounds were given by subcutaneous or intraperitoneal injection to adult male mice in order to find out which of them possessed the selective activity exhibited by trimethylhexadecylammonium stearate on the gastro-intestinal mucosa. Afterwards, some of these substances were incorporated in diet 41 in various concentrations and fed to mice, each of the animals receiving 5 gm. of diet a day. All the mice used were from non-interbred albino *C* stock. Tissues for histological study were only taken from animals killed when moribund.

Cationic Compounds

Cetrimide. Some of the results obtained after subcutaneous injections of cetrimide are given in Table 1. The *LD*50 of the bromide ester administered by this route was some ten times smaller than that of the stearate. There was always brown staining at the site of injection. After the smaller doses, mice died in 1–5 days and invariably showed reddish brown or coffee-ground hæmorrhages in the pyloric part or the whole of the stomach, in the duodenum, jejunum and sometimes the ileum, but not in the cæcum or colon (Figs. 1–3). Mice receiving the larger doses of cetrimide died in a matter of minutes or hours and failed to show gastro-intestinal hæmorrhage; but the duodenum was intensely stained with bile and the intestines contracted.

These findings, noted after doses of 0·25–1·0 gm./kgm., and the occasional occurrence of convulsions with varying degrees of auriculo-ventricular block, were considered compatible with an acetylcholine effect. This was confirmed by studies on the blood pressure of the cat and on the motility of strips of rat intestine. In both biological tests the potency of cetrimide was about 10^{-3} or 10^{-4} of that of acetylcholine, but the drug seemed to block itself rapidly.

Surviving animals were killed some 2–3 months after the injection and carefully examined, but no abnormality was ever detected.

When cetrimide was given intraperitoneally in doses of 0·075 gm./kgm., death occurred with convulsions within 3–5 min., but even doses of 2 mgm./kgm. caused 100 per cent mortality in about 12–15 hr. The largest doses which mice survived were 1·5 and 1 mgm./kgm., and thus cetrimide was some 50 times more toxic by the intraperitoneal than by the subcutaneous route. For the stearate ester the corresponding factor was about 10.

When cetrimide was administered orally in diet 41, however, it proved no more toxic than trimethylhexadecylammonium stearate (Table 2). It seemed unlikely that this result was due entirely to poor absorption of the cetrimide from the alimentary canal, so that inactivation of the compound by gastro-intestinal juices and/or food was presumed to occur. The ratio of intraperitoneal to oral activity was of the order of 2,000 : 1.

Domiphen bromide. This substance was administered by subcutaneous injection only (Table 1). Its *LD*50 was about 0·125 gm./kgm., or 5/3 that of cetrimide. All postmortem findings, including the histological changes in the gastro-intestinal mucosa, were similar to those after cetrimide.

Anionic Compounds

Sodium stearate. Given both subcutaneously and intraperitoneally in single doses of 0·5 and 1·0 gm./kgm., this compound was distinctly devoid of

Table 1. Effect of some Surface-active Substances administered to Mice by Subcutaneous Injection

Drug	Dose (gm./kgm.)	No. of mice	Percentage mortality	Percentage incidence of hæmorrhage in intestine
Trimethylhexadecylammonium stearate	0·50	10	20	—
	0·75	20	60	40
	1·00	30	92·5	100
Cetrimide	0·075	10	50	100
	0·100	10	70	100
	0·150	10	100	100
	0·188	12	100	67
	0·250	2	100	0
	0·500	2	100	0
	1·000	2	100	0
Domiphen bromide	0·100	10	30	100
	0·150	10	70	100
	0·200	10	90	—
	0·250	2	100	50
	0·500	6	100	33
	1·000	2	100	0
Sodium lauryl sulphate	0·100	2	0	0
	0·200	2	0	0
	0·500	2	0	0
	1·000	2	0	0
	2·000	2	0	0

Table 2. Loss of Weight and Period of Survival of Mice on Different Concentrations of Some Surface-active Substances in the Diet

Drug	Conc. of drug in diet (gm. per cent)	No. of mice	Average original weight (gm.)	Average weight at 1 month (gm.)	Average change in weight (gm.)	Survival period in days
Trimethylhexadecyl-ammonium stearate	0·00	24	23·5	23·1	− 0·4	indefinite
	0·05	30	23·7	23·6	− 0·1	90 or more
	0·10	24	23·5	21·7	− 1·8	60 or more
	0·20	24	23·4	20·0	− 3·4	17–35
	0·40	12	23·3	18·4	− 4·9	11–20
Cetrimide	0·00	6	26·7	27·3	+ 0·6	indefinite
	0·05	6	26·1	26·5	+ 0·4	indefinite
	0·10	6	26·1	25·5	− 0·6	indefinite
	0·20	6	26·5	22·5	− 4·0	35–63
	0·40	6	26·8	20·3	− 6·5	9–12
Sodium stearate	0·00	4	29·8	28·5	− 1·3	indefinite
	0·50	4	29·9	29·5	− 0·4	indefinite
Sodium lauryl sulphate	0·50	6	28·0	28·0	0·0	indefinite
	1·00	6	27·9	25·9	− 2·0	indefinite
	2·00	6	27·4	19·5	− 7·9	3–4

any adverse effect on the thirteen animals used, and no loss of weight was noted. When killed 1–2 months after the injection, these mice differed in no way from the controls. The substance was also given to 16 animals in a concentration of 0·5, 1, and 5 per cent in diet 41. The results leave no doubt that for all practical purposes the gastro-intestinal activity of trimethylhexadecylammonium stearate is invested entirely in the cationic part of the molecule.

Sodium lauryl sulphate. Subcutaneous doses of 0·1, 0·2, 0·5, 1 and 2 gm./kgm. of this compound were each given to two mice. Large skin ulcers, at first surrounded by œdema, appeared in the same day after the injection of the largest three doses. The ulcers did not perforate to the peritoneum, which was evidently resistant to this action, and there was no evidence of systemic disturbance after the injection. The animals remained alive and well and the ulcers healed in about six weeks. Intraperitoneal injections of 0·2 and 0·4 gm./kgm. were each given to four mice. The animals receiving the larger dose died within 1–3 days, but postmortem revealed no consistent pathological abnormality to indicate the cause of death.

The results obtained with oral feeding of sodium lauryl sulphate in concentrations of 0·5, 1 and 2 per cent are of fundamental importance. Death supervened within four days in the group receiving the highest concentration, and all six animals showed typical gastro-intestinal hæmorrhage associated with marked loss of weight, just as in the case of cetrimide and domiphen. However, the toxic dose was critical, as no adverse effects were noted after the two smaller concentrations of 0·5 and 1 per cent even in experiments lasting some three months. Animals receiving 1 gm./kgm. of this drug showed a transient loss of weight averaging 2 gm. per mouse at five weeks.

Non-ionic Compounds

Both sorbitan monostearate ('Span 60') and polyoxyethylene sorbitan mono-oleate ("Tween 80') were given as a 10 per cent aqueous suspension and solution respectively by subcutaneous injection to mice in doses of 1, 4 and 8 gm./kgm. No loss of weight followed, the animals remained healthy, and nothing abnormal was found when the animals were killed four weeks later. Doses of 1 gm./kgm. of 'Tween 80' given by stomach tube to three mice did not cause gastro-intestinal hæmorrhage.

Simpler Quaternary Ammonium Compounds

Tetraethylammonium bromide and hexamethonium chloride were tested in subcutaneous doses ranging from 20 to 200 mgm./kgm. The animals either died in 10–60 min. and failed to show any injury to the gastro-intestinal mucosa or survived the dose and showed nothing abnormal when killed a week later.

Discussion

The above results indicate clearly that the activity of trimethylhexadecylammonium stearate with regard to the gastro-intestinal mucosa is invested mainly, and may be entirely, in the cationic part of the molecule. The related substance domiphen bromide possesses the same effect. If the side-chain of the quaternary ammonium compounds is shortened or removed, this activity is abolished. It is possible, however, that such an effect is still invested in the quaternary ammonium structure and may be revealed by investigating less-soluble esters of the compounds, for example, tetraethylammonium stearate. The fact that this action on the gastro-intestinal mucosa may also result from the administration of the non-quaternary–ammonium anionic sodium lauryl sulphate strongly suggests that the activity is a feature of an ionic (cationic or anionic) long-chain structure, particularly as the non-ionic compounds tested gave entirely negative results.

A point of great interest is that in the case of sodium lauryl sulphate the gastro-intestinal effect disappeared completely when the dose was reduced from 2 to 1 gm./kgm. In other words, with this compound the effect appears abruptly and maximally at a critical dose. In the case of the cationic quaternary ammonium surfactants, the range of activity was at least 2–3 times that of sodium lauryl sulphate, so that halving a maximally toxic dose twice did not abolish the effect. The fact that such gradation in activity is possible is a useful indicator for future research, since an even greater grading of response may be expected to be associated with decreased toxicity.

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REDUCTION OF THE INTESTINAL ABSORPTION OF GLUCOSE, METHIONINE AND SODIUM BUTYRATE BY THE CATION TRIMETHYLHEXADECYLAMMONIUM

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In two preceding publications[1] it was shown that some ionic surface-active compounds, including the stearate and bromide of trimethylhexadecylammonium, have definite structural effects on the gastro-intestinal mucosa. Interference with the absorptive function of the intestine was also presumed. In this article an account is given of the effect of these compounds on the intestinal absorption of glucose, methionine, sodium butyrate and water, as studied in more direct experiments.

The methods used in the study of the effect of the trimethylhexadecylammonium cation on intestinal absorption are convenient modifications of the method described by Jervis *et al.*[2]. The different nutrient substances were perfused in normal saline, with or without the drug, through the intestine of rabbits or albino rats and circulated by a flow of moist oxygen from a cylinder. The animals were anæsthetized with sodium pentobarbitone, the gut washed with warm saline and emptied. A length of small intestine consisting of the duodenum plus a piece of jejunum, about 2 ft. long in the rat and 3 ft. long in the rabbit as measured from the duodeno-jejunal flexure, was perfused with a known volume of the fluid under study. At the end of each experiment the perfusate was drained into a flask, its volume measured, and the amount of fluid absorbed or secreted per hour calculated. The length of the perfused intestine was then removed and measured accurately. From the difference between the initial quantity of each of the substances perfused and the final amount recovered, the percentage absorption was calculated.

The different solutions used were approximately neutral, their *p*H values ranging from 6·7 to 7·7.

Glucose was estimated by the modified Schaffer–Hartman method of King[3], methionine by the method of McCarthy and Sullivan[4], and sodium butyrate by the method of Smyth and Taylor[5]. Perfused and non-perfused duodenum and jejunum were fixed either in formol-saline or in ice-cold 80 per cent alcohol at the end of the experiment for histological study.

The experiments may be divided into two groups according to duration of perfusion: 2-hr. perfusion experiments, and half-hour perfusion experiments.

Two-hour Perfusion Experiments

The control perfusion fluid consisted of normal saline containing either 0·3 per cent glucose and 0·3 per cent methionine together or 0·3 per cent sodium butyrate alone. 250 and 125 ml. of fluid were perfused in the case of rabbits and rats respectively. Trimethylhexadecylammonium stearate was added to the perfusion fluid to give concentrations of 0·1 and 0·5 per cent, while cetrimide was used in concentrations of 0·01 and 0·1 per cent. Samples of perfusate for glucose and methionine, or butyrate estimations, and samples of blood for glucose estimations were taken at 0, 1 and 2 hr. Perfusion pressure was 10–12 cm. at the duodenal end, but only just above zero at the distal end. The rate of flow was kept at 20–40 ml./min. by adjusting the oxygen flow. The bile duct was included in some experiments and excluded in others.

Rats. This group comprised four control rats and eight rats perfused with the control solution containing the drug in the form of the stearate ester. Four of the latter received 0·1 per cent and four received 0·5 per cent of the drug, but since the results obtained with the two concentrations did not differ significantly, they have been grouped together for simplicity (Table 1, Fig. 1). The absorption of glucose and of methionine fell to one-half and one-third respectively with the addition of the drug, and the absorption of water was likewise diminished. Furthermore, in spite of wide variations in the levels of blood sugar under the conditions of the experiment, there was a net rise of 32 mgm./100 ml. in the control group and a net fall of 6 mgm./100 ml. in the treated group, a result compatible with the more rapid rate of absorption of glucose in the former. To counter the suggestion that the decreased rate of disappearance of glucose from the perfusate under the influence of the drug was due to decreased utilization by intestinal bacteria, a suspension of some 15–20 per cent of the intestinal contents of a rat in 125 ml. of the control solution was circulated in the apparatus for 2 hr.,

Table 1. Absorption of Glucose, Methionine, Butyrate and Water and Rise in Blood Glucose in 2-hr. Perfusion Experiments. Figures represent Mean ± *S.E.*

	Rats		Rabbits	
	Control (4 exp.)	0·1 and 0·5 per cent TAS* (8 exp.)	Control (19 exp.)	0·1 per cent centrimide (6 exp.)
Percentage absorption of glucose	61·6±3·3	30·5±1·8 $P \ll 10^{-3}$	53·0±3·6	−6·0±7·8 $P < 10^{-4}$
Rise in blood glucose (mgm./100 ml.)	31·9±7·8	−5·9±8·5 $P < 0·02$	62·4±6·3	20·8±10·9 $P \simeq 0·002$
Percentage absorption of methionine	59·1±2·9	18·7±2·9 $P \ll 10^{-3}$	54·9±3·8	54·1±5·1
Fluid absorption (ml./hr.)	6·5±0·5	1·0±0·8 $P \simeq 10^{-3}$	5·8±2·5	−5·9±3·1 $P \simeq 0·02$
Length of perfused intestine (cm.)	74·8±3·5	73·8±2·4	140·0	150·8
Percentage absorption of butyrate			38·1±2·8 (3 exp. only)	34·9±11·0 (3 exp. only)

* TAS = Trimethylhexadecylammonium stearate.

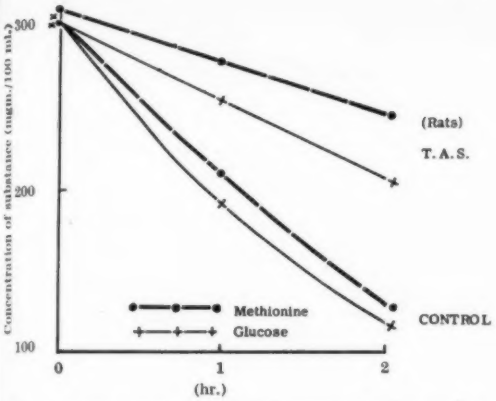


Fig. 1. Curves showing rate of disappearance of glucose and of methionine from perfusate in four control rats and eight rats receiving 0·1 or 0·5 per cent trimethylhexadecylammonium stearate in 2-hr. perfusion experiments

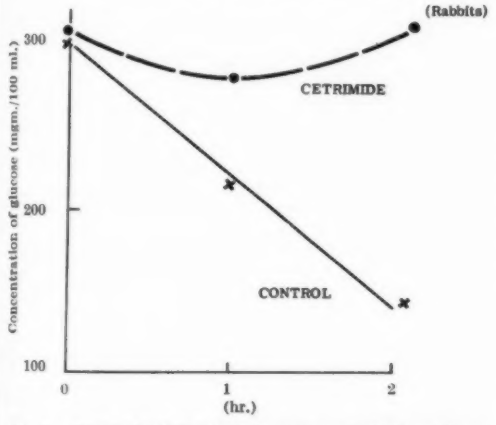


Fig. 2. Curves showing rate of disappearance of glucose from perfusate in nineteen control rabbits and six rabbits receiving 0·1 per cent cetrimide in 2-hr. perfusion experiments

but no measurable change was noted in the glucose concentration at the end of the experiment.

Rabbits. This group comprised initially nine control rabbits. The perfusion of 0·1 per cent trimethylhexadecylammonium stearate in seven rabbits, with and without 0·06 per cent hydrochloric acid or bile, did not inhibit the absorption of either glucose or methionine. Similarly, the perfusion of 0·01 per cent cetrimide in three rabbits had no effect. These 10 rabbits were therefore included in the final control group, which now comprised 19 experiments. Six rabbits were then given 0·1 per cent cetrimide in the perfusion fluid, and here the results as regards glucose absorption were striking, but the absorption of methionine remained unaffected. In three of the six rabbits the glucose titration readings were in fact greater for the final sample than for the first, and if the reducing material is accepted as wholly glucose, the excess sugar recovered in the perfusate equalled 125, 159 and 212 mgm. respectively, so that in the last hour the direction of net flow of glucose was from the blood to the intestine (Table 1, Fig. 2).

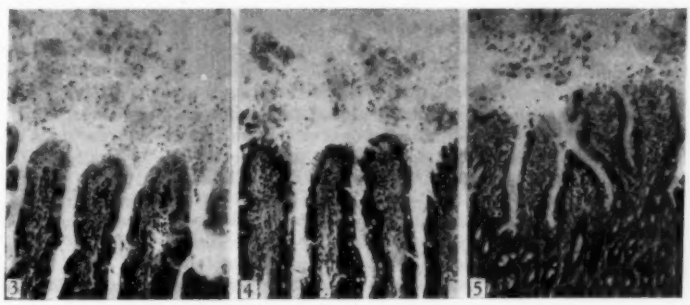
Three control rabbits were given 0·3 per cent sodium butyrate in normal saline but no glucose, and three were given the same solution containing 0·1 per cent cetrimide. There was no inhibition of the absorption of the short-chain fatty acid as is evident from Table 1, but although no glucose could be demonstrated in the perfusate of the control rabbits at any time, reducing material began to appear at 1 hr. in the perfusate of the rabbits receiving cetrimide and the total recovered at 2 hr. for the three rabbits was equivalent to 220, 306 and 391 mgm. glucose.

Finally, in one experiment, 0·1 per cent glucose-free solution of cetrimide in normal saline was perfused in a rabbit for 6 hr. Titration readings for glucose on the perfusate gave the values of 0, 23, 75, 104, 116, 122 and 133 mgm./100 ml. at 0–6 hr. The 2-, 4- and 6-hr. values of 75, 116 and 133 mgm./100 ml. were checked by the specific glucose oxidase method of Huggett and Nixon[8], and the respective values 80, 108 and 127 mgm./100 ml. were obtained. The close agreement between the two sets of figures identifies the reducing substance as mainly if not entirely glucose.

125 and 250 mgm. cetrimide given subcutaneously to two rabbits, both weighing 2 kgm., did not cause glycosuria, so that in comparable doses this substance does not appear to possess the obvious blocking effect of phloridzin on the absorption of glucose by the renal tubules. Conversely, a perfusion experiment in which 0·1 per cent phloridzin was used reduced the intestinal absorption of glucose only to 25 per cent and had no effect either on methionine or on butyrate absorption.

Half-hour Perfusion Experiments

Only rats were used here, and the perfusion fluid consisted of 50 ml. of normal saline containing 0·2 per cent each of glucose, methionine and sodium butyrate, which were studied together. The drug concentrations were the same as in the 2-hr. experiments. Blood samples were collected from the tail at the beginning and end of each experiment, and the change in blood sugar noted; but perfusate samples were estimated for sugar, amino-acid and fatty acid only at the end. The hydrostatic pressure was kept at 7–10 cm. at the duodenal end, and the rate of flow at 10–20 ml./min. The bile duct was included in all experiments.



Figs. 3–5. Intestinal mucosa of rats after perfusion for 2 hr. (× 75)
(3) Control solution. (4) 0·1 per cent trimethylhexadecylammonium stearate.
(5) 0·1 per cent cetrimide

Table 2. Absorption of Glucose, Methionine, Butyrate and Water and Rise in Blood Glucose in ½-hr. Perfusion Experiments in Rats. Figures represent Mean ± S.E. of Four Experiments

	Control	0·1 per cent TAS	0·5 per cent TAS	0·01 per cent cetrimide	0·1 per cent cetrimide
Percentage absorption of glucose	39·4 ± 2·5	30·1 ± 2·6 $P < 0·05$	24·7 ± 1·0 $P \simeq 10^{-3}$	29·3 ± 3·3 $P = 0·05$	5·4 ± 2·4 $P < 10^{-4}$
Rise in blood glucose (mgm./100 ml.)	117·5 ± 22·3	72·3 ± 20·0 $P \simeq 0·1$	56·2 ± 22·8 $P \simeq 0·1$	83·9 ± 8·1 $P \simeq 0·4$	33·3 ± 13·1 $P < 0·02$
Percentage absorption of methionine	43·9 ± 1·8	32·3 ± 1·9 $P < 0·01$	18·2 ± 2·1 $P < 10^{-4}$	30·4 ± 2·5 $P < 0·01$	13·3 ± 2·5 $P < 10^{-4}$
Percentage absorption of butyrate	58·9 ± 2·7	37·1 ± 4·3 $P < 0·01$	22·9 ± 1·7 $P < 10^{-4}$	33·8 ± 1·2 $P < 10^{-4}$	17·3 ± 1·5 $P < 10^{-4}$
Fluid absorption (ml./hr.)	5·9 ± 0·8	1·8 ± 1·0 $P < 0·02$	2·7 ± 0·6 $P < 0·02$	1·3 ± 0·5 $P < 0·01$	− 1·8 ± 0·9 $P < 10^{-2}$
Length of perfused intestine (cm.)	62·5 ± 0·7	65·3 ± 2·8	62·3 ± 2·9	65·3 ± 3·4	66·0 ± 3·2

TAS = Trimethylhexadecylammonium stearate.

The results obtained in five groups of four rats are given in Table 2. The five groups comprised a control group and four others in which the animals received in addition 0·1 and 0·5 per cent of the stearate ester and 0·01 and 0·1 per cent of the bromide ester in the perfusion fluid. The effect of the cationic trimethylhexadecylammonium of both esters on the absorption of water, glucose, methionine and butyrate can scarcely be questioned.

In all experiments with this cation the secretion of mucus by the intestine was increased as compared with the control, and the effect seemed proportional to the activity and concentration of the drug.

Histological Results

In 2-hr. perfusion experiments, both in control and treated animals, large numbers of cells appeared in the lumen of the gut and consisted chiefly of leucocytes and shed epithelial and mucus cells; but, in addition, rabbits perfused with 0·1 per cent cetrimide showed definite damage to the intestinal villi. In half-hour perfusion experiments, the number of cells in the lumen was markedly less and scarcely differed from non-perfused control intestine. Similarly, rats perfused with 0·1 per cent trimethylhexadecylammonium stearate did not differ significantly from either, but those perfused with 0·5 per cent of the stearate ester and with 0·01 per cent of the bromide ester showed a significant increase in cells shed and those receiving 0·1 per cent cetrimide showed frank damage to the intestinal mucosa (Figs. 1–3).

Discussion

The most striking and consistent effect of trimethylhexadecylammonium was on the absorption of glucose, which at a concentration of 0·1 per cent of the bromide ester appeared to be completely inhibited. At this concentration cetrimide is described as non-irritant to tissues[7]; however, the injury to the intestinal villi in these experiments was unmistakable. An interesting feature was the marked differences in species with regard to their sensitivity to the inhibitory action on glucose absorption. There was, in addition, the interesting absence of an inhibitory effect on the absorption of methionine and sodium butyrate in the rabbit, though the effect on the absorption of glucose was more or less as pronounced as in the rat. Furthermore, it is evident that the inhibitory effect on absorption was not related to the degree of injury caused by high concentrations of this cation, as the absorption of methionine and butyrate continued at high concentrations in the rabbit, but failed at low concentration in the rat. This is an important finding, and in the search for new compounds the aim should be to widen this gap still further.

The results of perfusion experiments reported here support the earlier conclusion[1] that large doses lead to structural damage, while small doses "appear to reduce the functional efficiency of the mucosal cell". The functions of the mucosal cells are presumed to be mainly enzymic in nature. In the present investigation, the marked species differences point clearly to specific enzyme actions being involved in the functional inhibition of activity.

The concentrations of the stearate ester used in the perfusion experiments have been of the same order as those used in feeding experiments, but in assessing the significance of histological injury to the intestinal mucosa it should not be assumed that the same conditions prevail for the action of the drugs in both cases. It is quite clear, for example, that cetrimide in the rat is at least ten times and probably a hundred times as active in perfusion as in feeding experiments in which the drug is incorporated with diet 41. It is possible that the inhibition of absorption, which in all probability depends on the uptake of the cation by specific enzymes, can be achieved slowly in a feeding experiment as the ester is gradually solubilized in the intestine to inactivate more and more enzyme molecules. On the other hand, structural damage of villus cells, which evidently differs in its mechanism from that of inhibition of absorption, may be more directly related to the actual concentration of the cation present in the bathing fluid.

I should like to thank Mrs. Miriam Thurlow and Miss Myra Jones for their expert and willing technical assistance, Mr. L. Westwood for invaluable help, particularly in the preparation of the histological sections, and Prof. W. J. H. Butterfield and Miss Margaret Wichelow for carrying out check glucose estimations by the oxidase method.

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LETTERS TO THE EDITORS

PHYSICS

Effect of a Resisting Couple on the Rotational Motion of a Rigid Body

THE examination of the effect of external couples upon the rotational motion of artificial Earth satellites has been of interest, in view of the rapidity with which their instantaneous axes of rotation have been observed to approach the axis of greatest moment, even when they have been initially spun about the axis of least moment. In this particular problem the role of internal energy dissipation due to non-rigidity may in fact be important, but, setting this aside, the theorem set out below appears relevant. This states a well-known principle and many of its corollaries have been proved; however, I have been unable to trace any direct reference to the proposition, or its converse, and would be grateful if any reader could do so.

The proposition is as follows. An external couple applied for a discrete time to a rigid body about its instantaneous axis of rotation in the sense opposing its rotation tends to cause that axis to approach the axis of greatest moment (provided that the instantaneous axis is not initially that of a permanent rotation).

In regard to the proof, we note that if $\mathbf{h}$ is the vector moment of momentum, and $\mathbf{w}$ the angular velocity, then the kinetic energy of the rotation is:

$$T = \tfrac{1}{2}\mathbf{h}.\mathbf{w} \qquad (1)$$

and in the free motion following the application of the couple, the invariable line intersects the surface of the ellipsoid of gyration at points distant $(h^2/2MT)^{1/2}$ from its centre (M being the body mass). Thus the value of $(h^2/2T)$ is bounded above and below by the greatest and least moments of inertia, and such limit values denote respectively a permanent rotation of the body about the axes of greatest and least moment in the free motion. Further, within these bounds, an increase in $(h^2/2T)$ would imply a change in the free motion consisting of an expansion of the invariable cone about the axis of least moment, and/or a contraction about that of greatest moment. The corresponding change in configuration of the polhode cone is analogous, as it is an affine transformation of the invariable cone.

Interpreting such a change in the motion to be that implied in the theorem, its proof is as follows. From the equations of motion we deduce that, if $\mathbf{G}$ is the couple, then during its action:

$$\mathbf{w}.\mathbf{G}. = \frac{\mathrm{d}T}{\mathrm{d}t} \qquad (2)$$

$$2\mathbf{h}.\mathbf{G}. = \frac{\mathrm{d}h^2}{\mathrm{d}t} \qquad (3)$$

Consequently it follows from (2) and (3) that:

$$T^2\frac{\mathrm{d}}{\mathrm{d}t}(h^2/T) = 2T(\mathbf{h}.\mathbf{G}.) - h^2(\mathbf{w}.\mathbf{G}.)$$

or using equation (1), the right-hand side may be rearranged to give:

$$\left.\begin{aligned}\frac{\mathrm{d}}{\mathrm{d}t}(h^2/2T) &= \tfrac{1}{2}(\mathbf{G}\times\mathbf{h}).(\mathbf{h}\times\mathbf{w})/T^2\\ &= \tfrac{1}{2}[\mathbf{G},\mathbf{h},\mathbf{h}\times\mathbf{w}]/T^2\end{aligned}\right\} \qquad (4)$$

If, as in the proposition, $\mathbf{G}$ is opposite to $\mathbf{w}$, then $(h^2/2T)$ is increased while the couple acts and remains constant thereafter, unless $\mathbf{h}\times\mathbf{w} = 0$, which would indicate a rotation about a permanent axis. It may further be shown that the value of $(h^2/2T)$ increases asymptotically to its upper bound as the total applied wrench is indefinitely increased.

The converse of the theorem may be stated as follows. If the instantaneous axis, not being initially permanent, is caused to approach the axis of greatest moment by the action of an external couple, then for some discrete time the resolved component of that couple about the instantaneous axis opposes the motion.

For we may, without loss in generality, compound the couple of three non-planar components, one in the direction of the vector $\mathbf{h}\times\mathbf{w}$ (which exists if the instantaneous axis is non-permanent), another in the direction of the moment of momentum and one in the direction of the instantaneous axis. By (4), only the last-named component affects the rate of change of $(h^2/2T)$, and since $(h^2/2T)$ is increased, this component must be sensed in opposition to $\mathbf{w}$.

Thus, the instantaneous axis of rotation of a rigid body, not being initially a permanent axis, approaches the axis of greatest moment if, and only if, the body is acted on for some discrete time by a resisting couple about the instantaneous axis. A body subjected to a continuous resisting couple about the instantaneous axis is unstable in an initial motion about the permanent axis of least moment, but stable about that of greatest moment.

An exactly analogous proposition and converse exists in relation to an accelerating couple, the body then tending to rotate about the axis of least moment.

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A Relation between Ultra-sonic Velocity and Latent Heat of Vaporization

SEVERAL attempts have been made by different investigators to find the relation between ultra-sonic velocity in liquids and the physical properties. One such relation has been obtained by Rao[1] empirically. Recently, Kishimoto and Nomoto[2] have obtained a relation between temperature coefficient of ultra-sonic velocity and boiling point of a liquid. In this communication we present a new relation between ultra-sonic velocity and latent heat of vaporization.

For this investigation we have used ultra-sonic velocity data taken from the literature for about

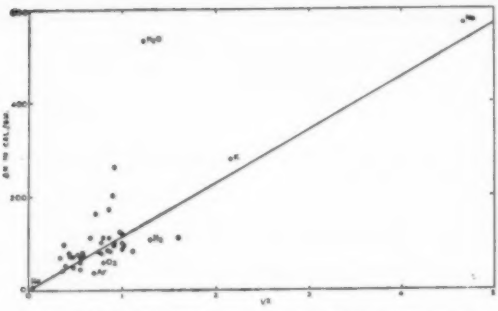

Fig. 1. Relation between ultra-sonic velocity and heat of vaporization

forty-five liquids in addition to some measurements which we have made on liquids not included in the literature. We have included a few liquefied gases and molten metals. In the first instance the values of the latent heats of vaporization L_v were plotted against the ultra-sonic velocities at 30° C., but as there was no sign of linearity in the graph, the values of L_v were replotted against the square of the ultra-sonic velocity V. It was found that the observations gave a fairly linear graph. To see if the linearity of the plot of points improves, the values of the latent heats at boiling point are again plotted against the extrapolated ultra-sonic velocities at temperatures where the molar volume of the saturated vapour of the liquid is 22·4 l., and this plot (Fig. 1) shows a better degree of linearity. A smooth line is drawn so as to pass through the maximum number of points, and using the gradient of this straight line the following empirical relation is obtained :

$$L_v = 133\ V^2$$

where L_v is in cal./gm. and V in km./sec. If L_v is expressed in ergs/gm. and V in cm./sec., this relation reduces to the simple form $L_v \approx \frac{1}{2}V^2$.

It may be noted that significant deviations from the linear graph are observed only in the case of highly associating liquids like water, alcohols and organic acids. It is in any event expected that these liquids would not show such a simple relation in view of the molecular associations and complexes formed. It is significant that these deviations are always on the higher side of L_v as expected, and the excess over the value from the linear graph may be regarded as giving some idea of the association energy.

We have been able to deduce this relation theoretically by using the equation of state of a liquid obtained by Wentorf, Buehler, Hirschfelder and Curtiss[3] based on Lennard-Jones and Devonshire's liquid model[4], and utilizing also Trouton's rule modified by Hildebrand and the relations deduced by Kishimoto and Nomoto[2]. A detailed paper embodying these results will shortly be published elsewhere.

We are indebted to the Council of Scientific and Industrial Research for financial assistance in this research work.

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CRYSTALLOGRAPHY

Macroscopic Swelling of Vermiculite Crystals in Water

Expanding lattice layer silicates belonging to the smectite and vermiculite groups form complexes with organic cations by replacement of the inorganic cations normally present in interlayer positions in these minerals[1–6]. The formation of a complex, and sometimes also the orientation of the organic ions within the lattice, can be inferred from changes in the basal spacing of the mineral as shown by X-ray diffraction.

During studies of a series of vermiculite-organic complexes, it was observed that single crystals of vermiculite containing interlayer butylammonium ions swell macroscopically when placed in water. Swelling is anisotropic and occurs in a direction perpendicular to the plane of the silicate layers, leading to an increase in volume of the order of 3,000 per cent. The swollen crystals are coherent and gel-like. Their shape and homogeneous appearance suggest that the 10-Å. thick silicate layers remain effectively parallel to one another on swelling, and the observed increase in thickness indicates a mean interlayer distance of several hundred angstroms. Low-angle X-ray diffraction examination of several swollen crystals, for which I am indebted to Drs. K. Norrish and J. A. Raussell-Colom, indicates that individual interlayer distances probably do not deviate markedly from the mean value.

In view of these results, it seems justifiable to derive the interlayer distance in swollen crystals directly from measurements of the change in thickness of a crystal before and after swelling. The data in Fig. 1 were calculated on this basis using a vermiculite from Kenya[7], and show that the swelling, which is reversible, can be controlled by varying the concentration of butylammonium ions in the external solution. At high concentrations, the interlayer distance is 9–10 Å. (d_{001} = 19·2 Å.), suggesting that the butylammonium ions are oriented at right angles to the silicate layers. When the external concentration is reduced to about 0·06 N, marked swelling develops rather suddenly, and spacings in the region of 170 Å. are found. Further dilution results in continuous swelling to a maximum of about 530 Å. at infinite dilution. In this latter region, the interlayer distance appears to be related linearly to the reciprocal of the square root of solution concentration.

The ability of single crystals of lithium-vermiculite to swell when immersed in water has been mentioned briefly on previous occasions[8,9]. Tests show that the

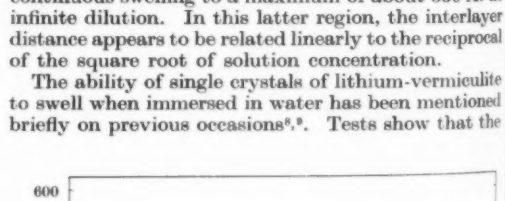

Fig. 1. Relationship between interlayer distance of butylammonium-vermiculite and concentration of butylammonium chloride in external solution (C = moles/litre)

degree of swelling in this system is also related to electrolyte concentration, but a tendency for the lithium-vermiculite crystals to exfoliate and break along cleavage planes during swelling makes measurements of changes in crystal thickness less reliable as an index of interlayer distance. Nevertheless, the indications are that, while the maximum amount of swelling is of the same order as that observed with butylammonium-vermiculite, the discontinuity in the curve, which occurs at about 0·15 *N* in this instance, leads to a relatively small 'step' of a few tens of angstroms. Apart from lithium and butylammonium, no other inter-layer ions tested so far cause extensive macroscopic swelling with water, although propylammonium ions produce limited swelling in certain vermiculites.

The swelling process in lithium-vermiculite recalls the swelling of aggregates of hydrogen-, lithium- and sodium-montmorillonites as studied by Norrish[9], and ascribed to the development of diffuse electrical double layers following upon the hydration and dissociation of the cations from the negative sites on the silicate layer surfaces. One may speculate that a similar mechanism operates in the butylammonium-vermiculite system, and that the sudden large expansion to an interlayer distance of 170 Å. at 0·06 *N* electrolyte concentration corresponds with the formation of 'icebergs'[10] around the butylammonium ions.

The highly oriented structure of these swollen crystals appears to offer a unique opportunity for examining the properties of water films of variable and known thickness associated with silicate layer surfaces, and further work on this and other aspects of these systems is in progress.

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Dislocations in Layer Structures

Amelinckx and Delavignette[1] have recently studied non-metallic substances with layer structures, including talc and graphite, by transmission electron microscopy. They observed nets of widely dissociated dislocations particularly in talc. Splitting into more than two partial dislocations in such hexagonal layer substances had been forecast by Kronberg[2]. Grenall[3] has observed dislocations in graphite previously, but did not observe dissociation into partials.

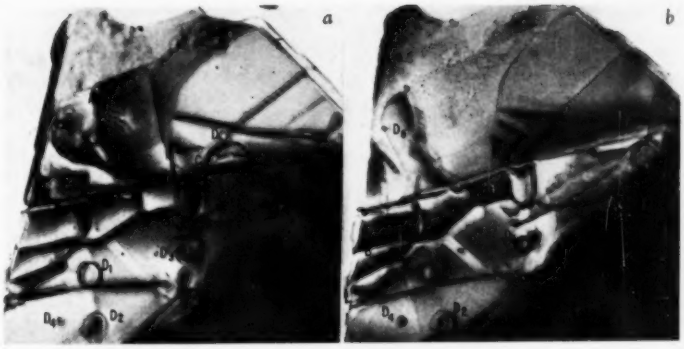

Fig. 1(*a*). Transmission electron micrograph of molybdenite flake. (*b*) As (*a*), but sample tilted about 1°. (× 62,000)

We have examined cleavage fragments of graphite and molybdenite for evidence of dislocations and have found that the interpretation of electron micrographs from such materials is rendered difficult by the presence of contrast effects due to extraneous surface detail such as steps and irregularities and by the presence of sub-grain boundaries. However, if a massive specimen is split in two, very thin and quite uniform leaflets can usually be found on the cleavage surfaces. Suitable leaflets of molybdenite which transmit in the red can be selected under the microscope using indirect illumination, and freed from the bulk with a fine needle. These specimens (about 1 cm. × 1 cm. × 1μ) are adequate for optical transmission studies[4], but are found still to consist of somewhat misoriented aggregations of sub-grains. When such specimens are exposed to ammonia vapour at − 78° C., a rapid absorption takes place, which results in a considerable weakening of the solid, so that these already thin pieces disintegrate easily into thinner fragments without undue mechanical damage. Fragments obtained in this way give reasonably interpretable results when submitted to transmission microscopy at high resolution in a Siemens 'Elmiskop I' electron microscope using 100 kV. Figs. 1*a* and *b* are an electron stereopair (tilt angle, 1–2°), obtained on molybdenite, which show a number of interesting features. A network of dislocations running vertically and spaced about 100 Å. is visible at *A* in Fig. 1*a* and disappears on tilting (Fig. 1*b*). A number of dislocations are visible at *B* (Fig. 1*b*). The prominent looped line feature at *C* in Fig. 1*a*, the contrast of which decreases in Fig. 1*b*, is probably also a dislocation. A number of interesting closed loops are visible at *D* in Figs. 1*a* and *b*. On tilting, some of the loops tend to change from single to double loops as at D_1; others show contrast reversal within the loop, as at D_2 and D_3. Loops with a dark centre spot are also observed at D_4 and D_5. The loops showing contrast reversal are thought to be dislocation loops enclosing stacking faults, although the details await further elucidation. Cleavage steps are visible at *E* (Fig. 1*a*).

Graphite flakes prepared by the above technique have not so far yielded results of similar interest, but recently we obtained a spectrographic graphite powder of high purity and a remarkable degree of order (grade *SPI*, National Carbon Co., New York, N.Y.). This material can be packed under moderate compression to give compacts of the density anticipated for a graphite single crystal, which is somewhat

Fig. 2. Transmission electron micrograph of graphite particle. (× 62,000)

unusual. The powder consists of well-defined hexagonal particles, about 10μ wide, the edges of which are sufficiently transparent to 100-kV. electrons to permit examination at high magnification. The plate-like particles frequently show moiré fringes indicating a rotational misfit between adjacent layers, which are presumably each some hundred angstroms thick. The perfection of the moiré patterns over distances of ¼–1μ (Fig. 2) indicates that regions of the layers up to this size are free from imperfection. A fourfold line detail some 600 Å. wide, which is probably a set of dislocations lying in the basal plane, may be seen running from *A* to *B* (Fig. 2), acutely inclined to the moiré fringes. A similar band of four lines can be seen running from *C* to *D*, increasing in width to a maximum of about 500 Å. as *C* is approached. Since graphite is a material of exceptionally low stacking fault energy, wide dissociation of dislocations into partials connected by stacking fault is to be expected. The two bands *AB* and *CD* are thought to consist of partial dislocations. The observation of four partial dislocations in graphite accords with the number expected from atomic considerations of the possible steps in the shear process.

A number of other features in Fig. 2 are worthy of note. *EF* is a dislocation which is roughly parallel to the band *CD* discussed above. *G* is a hexagonal loop which is about 1400 Å. long by 850 Å. wide. This is probably a dislocation loop. One pair of sides of this loop is parallel to the moiré fringes, another pair is parallel to the crystal edge *HJ*. The existence of hexagonal dislocation loops may be related to the observation by R. H. Savage (private communication) that thermal etching of graphite produces shallow hexagonal holes, and to the observation by one of us (P. C.) that chemical etching produces similar holes. Above *H*, a number of further dislocations are visible.

It appears to us that the search for dislocations in materials of this type is rewarding, but in the softer materials is very dependent on method of preparation of the sample.

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CHEMISTRY

Cage Effect in the Liquid-Phase Photolysis of Fluorinated Ketones

In a previous communication[1], the products of photolysis of 1 : 3 dichlorotetrafluoroacetone were described, and the absence of compounds which could arise from the reactions of the chlorodifluoroacetyl radical noted. It is assumed that in this behaviour the ketone is similar to hexafluoroacetone, which has been shown to dissociate on photolysis into two trifluoromethyl radicals and a molecule of carbon monoxide[2]. Acetone, on the other hand, has been shown to dissociate into an acetyl and a methyl radical when photolysed at room temperature[3].

It seems probable that the primary act in the photolysis of 1 : 3 dichlorotetrafluoroacetone is the production of two chlorodifluoromethyl radicals and a molecule of carbon monoxide, although the results do not rule out the possibility of the intervention of a short-lived chlorodifluoroacetyl radical.

This work has now been extended to two more fluorinated ketones, 1 : 1 : 3 : 3 tetrachlorodifluoroacetone and 1 : 1 : 3 trichlorotrifluoroacetone, and once again no trace of products which could arise from reactions of halogenated acetyl radicals was found among the photolysis products. It is assumed that either the primary act is dissociation into two radicals and a molecule of carbon monoxide or else the life-time of the halogenated acetyl radical formed is very short.

$$CF_2ClCOCCl_2F \xrightarrow{h\nu} .CF_2Cl + .CCl_2F + CO$$

$$CFCl_2COCCl_2F \xrightarrow{h\nu} 2.CCl_2F + CO$$

The ultra-violet absorption spectra are similar to that of 1 : 3 dichlorotetrafluoroacetone.

(Trichlorotrifluoroacetone $\lambda_{max.}$ 2950–3050 Å. $\varepsilon_{max.}$58 Tetrachlorodifluoroacetone $\lambda_{max.}$ 2900–3050 Å. $\varepsilon_{max.}$48)

The photolysis products of 1 : 1 : 3 : 3 tetrachlorodifluoroacetone have been shown to contain 1 : 1 : 2 : 2 tetrachlorodifluoroethane, which arises by the combination of the two dichlorofluoromethyl radicals.

The photolysis products of 1 : 1 : 3 trichlorotrifluoroacetone, on the other hand, were shown to contain three different halogenated ethanes arising from combinations of the two different radicals formed in the primary step.

$$2.CF_2Cl \rightarrow CF_2ClCF_2Cl (R_1R_1) \quad (1)$$

$$.CF_2Cl + .CCl_2F \rightarrow CF_2ClCCl_2F \ (R_1R_2) \quad (2)$$

$$2.CCl_2F \rightarrow CCl_2FCCl_2F (R_2R_2) \quad (3)$$

As in the case of 1 : 3 dichlorotetrafluoroacetone it has been found that the radicals produced in the primary act are capable of abstracting chlorine atoms from the unphotolysed ketone to yield the corresponding halogenated methanes.

$$.CCl_2F + CCl_2FCOCCl_2F \rightarrow CCl_2F + .CClFCOCCl_2F$$

$$.CCl_2F + CCl_2FCOCF_2Cl \rightarrow CCl_2F + [.CClFCOCF_2Cl \text{ or } CCl_2FCOCF_2]$$

$$.CF_2Cl + CCl_2FCOCF_2Cl \rightarrow CCl_2F_2 + [.CClFCOCF_2Cl \text{ or } CCl_2FCOCF_2]$$

With 1 : 1 : 3 : 3 tetrachlorodifluoroacetone the products of this secondary reaction are trichlorofluoro-

methane and a halogenated acetonyl radical, which can undergo further combination reactions.

The secondary reactions of chlorine abstraction are much more complex in the case of 1 : 1 : 3 trichlorotrifluoroacetone, for the two dissimilar radicals produced may each abstract chlorine from either end of the halogenated acetone to give dichlorodifluoromethane (R_1Cl), trichlorofluoromethane (R_2Cl) and two isomeric halogenated acetonyl radicals. The further reactions of these radicals lead to the formation of a complex mixture of halogenated ketones, propanes and butanes, most of them too involatile to be identified with the present analytical procedure. One of the propanes, 1 : 3 dichlorohexafluoropropane, however, was sufficiently volatile to be isolated and identified by a combination of gas chromatography and mass spectrometry. It has already been identified among the photolysis products of 1 : 3 dichlorotetrafluoroacetone. The mechanism of its formation is uncertain, but it may arise either as a product of the combination of difluorochloromethyl and tetrafluorochloroethyl radicals or through the intervention of a CF_2 radical.

Trotman-Dickenson[4] has pointed out that even when two radicals R_1 and R_2 are very dissimilar the ratio of their product is such that :

$$\frac{[R_1R_2]}{([R_1R_1][R_2R_2])^{1/2}} \simeq 2{\cdot}0$$

where R_1R_1, R_2R_2, and R_1R_2 are the products of reaction.

When 1 : 1 : 3 trifluorotrichloroacetone was photolysed in the gas phase the proportions of the three halogenated ethanes formed were such that this ratio was 1·9.

The irradiation with light from a high-pressure mercury vapour lamp of 1 : 1 : 3 trichlorotrifluoroacetone in the liquid phase at room temperature resulted, however, in the formation of the three halogenated ethanes in proportions such that :

$$\frac{[R_1R_2]}{([R_1R_1][R_2R_2])^{1/2}} = 2{\cdot}6$$

This result is explained on the assumption that the two unlike radicals are formed within a 'cage' of unphotolysed ketone molecules which restrict their free diffusion apart. This concept of the 'solvent cage' was first put forward by Franck and Rabinowitch[5] and has usually been invoked to explain low quantum yields on the basis of recombination within a cage. This work has been extended by Lampe and Noyes[6], who studied the recombination of iodine atoms. The kinetics of photolysis of these three ketones provide direct evidence for the existence of such an effect. In the photolysis of 1 : 1 : 3 trichlorotrifluoroacetone the radicals escaping from the cage may either combine with each other or abstract chlorine from the unphotolysed ketone. Thus the ketone provides both a physical and a chemical cage. The effect of chlorine abstraction is reduced if the ketone is diluted with a solvent from which no abstraction can take place. Thus when the ketone is mixed with an equal volume of perfluoro-2-ethyl-*cyclo*hexane and photolysed, the proportions of halogenated ethanes are such that :

$$\frac{[R_1R_2]}{([R_1R_2][R_2R_2])^{1/2}} = 2{\cdot}2$$

The effect of the chemical cage is demonstrated by the addition of 1 : 1 : 3 : 3 tetrachlorodifluoroacetone, which, providing more dichlorofluoromethyl radicals, should lower the ratio. In fact, because of the greater efficiency of the symmetrical ketone as a radical scavenger, the ratio of halogenated ethanes produced is such that :

$$\frac{[R_1R_2]}{([R_1R_1][R_2R_2])^{1/2}} = 3{\cdot}9$$

The effect of the physical cage is demonstrated by the use of perfluoro-*cyclo*hexane as a solvent. Solutions of 1 : 1 : 3 trichlorotrifluoroacetone in this solvent have a high viscosity and, when photolysed, smaller amounts of the symmetrical ethanes are formed so that :

$$\frac{[R_1R_2]}{([R_1R_1][R_2R_2])^{1/2}} = 2{\cdot}8$$

These results are supported by studies of the photolysis of mixtures of 1 : 3 dichlorotetrafluoroacetone and 1 : 1 : 3 : 3 tetrachlorodifluoroacetone in the liquid phase, although the situation is complicated by the fact that the rates of production of radicals are now different. After 30 min. irradiation of such a mixture no unsymmetrical ethane was formed and on prolonged photolysis the ratio gradually rose to 0·4. When t' e mixture was diluted with perfluoroethyl-*cyclo*hexane the ratio rose to a value of unity. In these cases it is the like radicals which are confined to the cage, thus reducing the amount of unsymmetrical ethane formed. If the assumption is made that, in the liquid phase, once a radical has escaped from the cage its combination reactions are governed by statistical factors alone, then an estimate of the proportion of the radicals escaping from the cage may be made. Thus if the number of radicals involved in the formation of the unsymmetrical ethane $[R_1R_2']$ (1 : 1 : 2 trichlorotrifluoroethane) outside the cage is calculated from the equation :

$$[R_1R_2'] = 2.([R_1R_2][R_2R_2])^{1/2}$$

and this is added to the number required to produce the two symmetrical ethanes R_1R_1 and R_2R_2 and the methanes R_1Cl and R_2Cl, this sum is the total number of radicals reacting outside the cage. The number reacting inside the cage is given by the difference between the number required to produce the total 1 : 1 : 3 trichlorotrifluoroethane and those required to produce the amount formed outside the cage. That is :

$$[R_1R_2]-[R_1R_2'] \text{ or } [R_1R_2]-2([R_1R_1][R_2R_2])^{1/2}$$

Thus the percentage of radicals escaping from the cage is given by :

$$\frac{[R_1Cl] + 2[R_1R_1] + 2([R_1R_1][R_2R_2])^{1/2}}{[R_1Cl] + 2[R_1R_1] + [R_1R_2]} \times 100$$

and

$$\frac{[R_2Cl] + 2[R_2R_2] + 2([R_1R_1][R_2R_2])^{1/2}}{[R_2Cl] + 2[R_2R_2] + [R_1R_2]} \times 100$$

The values quoted below are in good agreement with theoretical expectations and show that for two similar radicals the combination of which is not diffusion-controlled a direct measure of the efficiency of a solvent cage may be made.

Solvent	Percentage R_1 escaping	Percentage R_2 escaping
1 : 1 : 3 Trichlorotrifluoroacetone	91	89
Perfluoro-*cyclo*hexane	89	85
1 : 1 : 3 : 3 Tetrachlorodifluoroacetone	68	76

A complete account of the kinetics of the photolysis of these three ketones is published elsewhere.

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Photochemical Formation and Stability of the CF_2 Radical

Ten years ago, Barrow and co-workers observed the ultra-violet absorption bands due to the CF_2 radical, produced during an electrical discharge through fluorocarbon vapour, and commented on its probable stability[1]. Using high-intensity flash photolysis techniques, we have been able to photograph the transient formation and slow decay of the same absorption bands produced from some halogenated ketones. Under our experimental conditions, the strongest absorption bands can be detected as long as 20 msec. after the photolysis flash, confirming the great stability of CF_2 as compared with its analogue CH_2 (ref. 2).

The ketones, which included sym-tetrafluoro-dichloro-acetone, and 1 : 1 : 3-trichloro-trifluoro-acetone, were photolysed in the vapour phase with the full radiation from a silica discharge lamp; the addition of excess nitrogen ensured the maintenance of isothermal conditions. The manner in which CF_2 radicals could arise in these systems is intriguing, since CF_2 formation would not have been anticipated by analogy with hydrogenated ketones. Certainly, the primary process:

$$R_1COR_2 + h\nu \rightarrow R_1 + CO + R_2$$

occurs, since all the possible ethanes were detected by vapour phase chromatography and mass-spectrometric analysis of the reaction mixture following flash photolysis. However, the simultaneous occurrence of alternative primary steps, of the type:

$$CF_2ClCOCF_2Cl + h\nu \rightarrow CF_2ClCOCF_2\cdot + Cl\cdot$$

yielding substituted acetonyl radicals, has been verified by introducing oxygen as the coolant gas; with each ketone the well-known absorption bands of $ClO\cdot$ were detected immediately following the flash, confirming the primary production of $Cl\cdot$ atoms. (The formation of $ClO\cdot$ via substituted methyl radicals may be discounted, since it has been observed that the flash photolysis of brominated chloromethanes in the presence of oxygen gives rise to $BrO\cdot$, but not $ClO\cdot$, radicals[3].) It may be anticipated that the acetonyl radicals would be unstable, dissociating as:

$$CF_2ClCOCF_2\cdot \rightarrow CF_2Cl\cdot + CO + CF_2$$

thus accounting for the production of CF_2. In this respect, it is significant that no di-acetonyl has been detected among the reaction products. Furthermore, in view of the evident stability of CF_2 it is not unreasonable to suppose that the perfluoroketone molecule would rapidly dissociate.

Preliminary measurements on the decay of the CF_2 absorption suggest that it is zero order, supporting Barrow's suggestion that CF_2 radicals are removed by diffusion to the walls of the reaction vessel[1]. The gradual appearance of a permanent continuous background absorption after several flashes points to the accumulation of a polymeric layer of $(CF_2)_n$ on the reaction vessel windows. No tetra-fluoro-ethylene or volatile CF_2-telomers could be detected among the reaction products, and it would appear that CF_2 is extremely unreactive (compare the marked unreactivity of NF_2 as compared with NH_2).

A fuller account of this and related work in progress will be published at a later date.

We wish to thank Dr. J. R. Majer for the vapour phase chromatography and mass-spectrometric analyses, and Prof. J. C. Robb for his interest in, and encouragement of, this work. A. J. Y. thanks the Department of Scientific and Industrial Research for a maintenance award, and J. P. S. thanks the University of Birmingham for the award of an Imperial Chemical Industries fellowship.

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Dependence on Temperature of the Electrical Resistivity of Thermosetting Polymers

To-day's great usage of thermosetting polymers has served to emphasize the lack of fundamental data on the electrical and physical properties of these materials. With the exception of the data published by us[1,2], there is almost none available on the dependence on temperature of the electrical volume resistivity and on the activation energy for the electrical conduction process, E_c, in cross-linked polymers. Data of this type are of great importance not only in technological applications but also in the study of the physics and chemistry of these polymers. For example, it has recently been shown[1,2] that the dependence on temperature of the resistivity is a convenient index of the extent of polymerization. Also, recent work has shown that electrical resistivity measurements can be successfully employed in the study of the reactions and the determination of the extent of polymerization of composite solid propellants[3]. These experimental techniques can likewise be used to investigate the properties of organic semiconductors. It is the purpose of this communication to indicate briefly how these measurements can be accurately and rapidly made and to present typical results.

A continuous current monitoring device[4] is used to determine the dependence on temperature of the resistivity of the polymer. This instrument consists of a Keithley model 210 electrometer, a Keithley model 2008 decade shunt and a cell. The cell consists of two brass parallel plate electrodes separated by two small polytetrafluoroethylene spacers. With this instrumentation it is possible to monitor continuously the large change in resistivity (10^6–10^{16} ohm.-cm.) which may occur on heating a polymer. To assure optimum electrical contact, the liquid

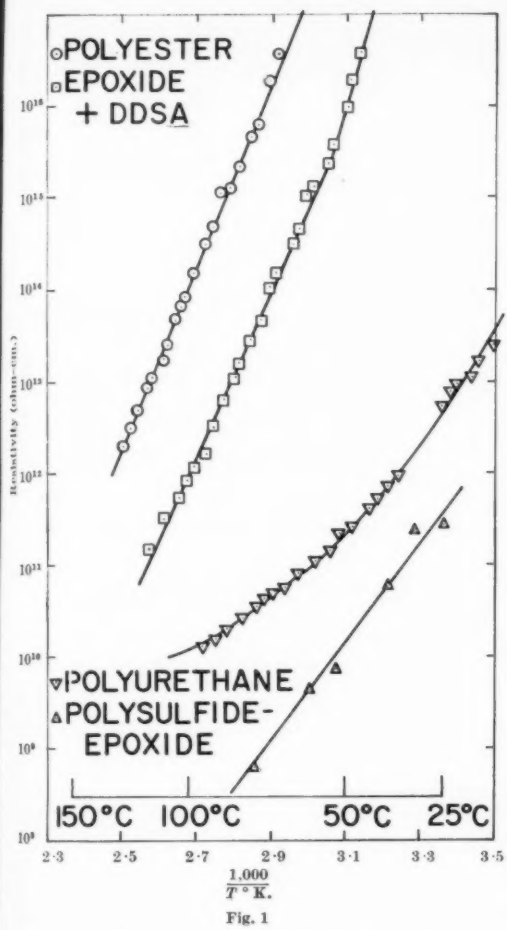

Fig. 1

polymer is polymerized directly to the electrodes which are encapsulated by the polymer. The dependence on temperature of the resistivity of the completely polymerized sample is determined by monitoring the resistivity and the temperature of the sample as it is heated at a rate of about 15° C. per hr. Measurements are made at a field-strength of about 200 V. per cm.

Polymers considered in this communication are typical of the thermosetting types in use. The epoxide was 'Epon 828' (Shell Chemical Co.), a reaction product of 2 moles of epichlorohydrin and 1 mole of *bis*(4-hydroxyphenyl) dimethylmethane[5], and had an epoxide value of 0·54 per 100 gm. It was polymerized with 59·5 per cent of dodecenyl succinic anhydride. The polyester was 'Paraplex *P*-43' (Rohm and Haas Co.), which is reported to consist of 30 per cent styrene and 70 per cent of a linear condensation polymer of maleic and phthalic acids with propylene glycol. This was polymerized using 1 per cent methyl ethyl ketone peroxide as a catalyst. The polysulphide-epoxide copolymer was a 50 : 50 mixture of a mercaptan terminated saturated elastomer and 'Epon 828'. The polysulphide was a reaction product of *bis*(2-chloroethyl) formal and sodium polysulphide[5]. Diethylaminopropylamine at a concentration of 3 per cent was used as a hardener. The polyurethane was a reaction product of a polyester glycol and 2,4-tolylene di*iso*cyanate which is cross-linked with 40 per cent castor oil.

It will be noted in Fig. 1 that in three of the polymers considered, the electrical volume resistivity, ρ, changes with the absolute temperature, T, in accordance with the general relationship:

$$\rho = \rho_0 \exp[E_c/RT]$$

where ρ_0 is a temperature-independent constant, R is the gas constant in cal./deg. mole, and E_c is the activation energy for the electrical conduction process. This activation energy was found to be 70 kcal./mole for the epoxide + dodecenyl succinic anhydride at temperatures below 54° C. and 43 kcal./mole above this temperature. The change in the slope of the resistivity versus temperature plot at 54° C. can be attributed to a glass transition within the polymer[6]. For the polyester polymer, E_c was 46 kcal./mole and for the polysulphide-epoxide copolymer 24 kcal./mole. A nonlinear temperature dependence of the resistivity is exhibited by the polyurethane which may be due to the internal plasticization of this polymer, probably by the excess castor oil.

All the resistivity versus temperature plots shown in Fig. 1 have the maximum slopes that can be obtained for these polymers. These plots, therefore, represent the greatest extent of polymerization possible.

It has been previously shown[1,2] that during polymerization the dependence on temperature of the resistivity increases as a function of the extent of polymerization. Thus, the dependence on temperature, or more conveniently E_c, is an index of the extent of polymerization. Prolonged heating at high temperatures or pyrolysis of these polymers will result in degradation, which is evidenced by a decrease in the slope of the resistivity versus temperature plot. It has been observed that thermosetting polymers generally exhibit a greater dependence on temperature and magnitude of the resistivity at 25° C. than linear polymers. The polysulphide-epoxide copolymer is an exception to this generalization.

Work is continuing in an effort to develop additional data and to broaden the use of the continuous current monitoring device to relate fundamental electrical properties to the structure and physical properties of thermosetting polymers. Additional data on thermosetting polymers, the experimental technique, and a discussion of the nature of the electrical conduction process in polymers will be published at a later date.

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'Enthalpy Titrations' and Thermochemistry in Molten Salts

Automatic instrumentation for recording 'thermometric titration' curves has been described in recent papers[1,2] from these laboratories, which represent the first report of a continuous titration procedure successfully carried out in a molten salt solvent. This approach is capable of yielding a wealth of quantitative information on the chemistry of fused salts. Significant thermochemical results, involving the precipitation of silver halides and of silver chromate, are summarized in this communication. A typical titration curve (of chromate with silver), obtained under essentially adiabatic conditions, is illustrated in Fig. 1. Methodologically this is a differential thermometric titration curve, because temperature has been recorded as a function of the amount of titrant. From a phenomenological point of view, however, Fig. 1 represents an 'enthalpy titration', the shape of the curve reflecting the heat evolved in the reaction as a function of added silver.

The following types of data can be inferred from a judicious interpretation of the titration curves: (*a*) The stoichiometry of the reaction occurring in the fused solvent, if concentrations of the reactants are known (the abscissa projection $B''C'$ represents a measure of the mole ratio of titrant to 'titrate' (Fig. 1) at the extrapolated end-point C). (*b*) The amount of reactant in a titrate of unknown concentration, provided the stoichiometry is known, and a standard solution of titrant is used. (*c*) The heat of the titration reaction, $\Delta H°$, calculated from the extrapolated change in temperature BB'. (*d*) The solubility product, K_{sp}, and the corresponding free energy of precipitation, $\Delta F° = RT\ln K_{sp}$, computed from the curvature in the vicinity of the end-point. (*e*) The entropy of the reaction, $\Delta S° = \dfrac{\Delta H° - \Delta F°}{T}$. Ideal thermodynamic parameters were obtained, because effective reactant concentrations in the titration cell were maintained in a range between 10^{-4} and 10^{-2} molal, where heats of dilution were found to be negligible. The change in temperature, BB', in a titration was of the order of 0·01–0·5° C., at mean temperatures of 500–800° K. The corresponding variability of the thermodynamic functions is negligible, yielding virtually isothermal enthalpies, free energies, and entropies, corresponding to the 'median temperature' of the titration curve, T (Fig. 1). The change in temperature during the titration was monitored in the titrated melt by means of a thermistor bridge having a sensitivity threshold of 0·0003° C. Random temperature fluctuations were minimized to ±0·0005° C. with the aid of a special adiabatic titration cell in a super-

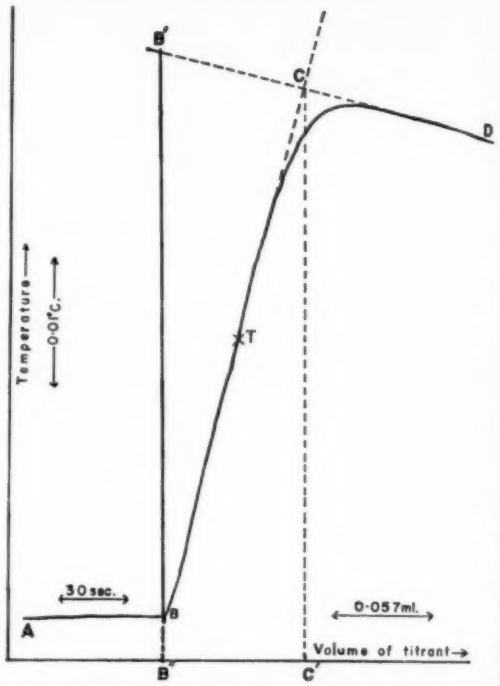

Fig. 1. Thermometric titration of $5·556 \times 10^{-4}$ *m*. K_2CrO_4 titrate with 12·78 *m*. $AgNO_3$ titrant in fused $LiNO_3$—KNO_3 at 431° K. Amount of titrate melt, 99·3 gm. *AB*, Temperature–time blank, prior to start of titration; *B*, start of titration; *C*, end-point, $2Ag^+/1CrO_4^{--}$; *CD*, excess reagent line; *T*, median temperature

natant argon atmosphere. The titrant was delivered by remote control, via a motor-driven syringe-burette. Titrant and titrate were dissolved in identical fused salt solvents[3].

A representative set of results is shown in Table 1. As is evident from column 3, thermometric titrations are applicable to quantitative volumetric analysis with a precision and accuracy of the order of 2 per cent, at concentration-levels as low as 10^{-3} molal. Extensive applications are anticipated to the determination of halides and silver, *in situ* in molten salts at elevated temperatures. Of the thermodynamic parameters, the entropies offer interesting possibilities for direct qualitative interpretation as a measure of order–disorder situations. For example, the fact that the precipitation of silver chromate at 431° K. was virtually anentropic in a fused alkali nitrate solvent suggests that chromate existed in the melt as an associated 'polychromate' species. In contra-

Table 1. Synopsis of Information obtained from Thermometric Titrations at 431° K.*
Titrant: Silver nitrate

Titrate	Titrate concentration (moles/1,000 gm. solvent melt)	End point stoichiometry† (silver/anion mole ratio)	Inferred reaction	Thermodynamic functions‡		
				$\Delta H°$ (kcal./mole)	$\Delta F°$ (kcal./mole)	$\Delta S°$ (cal./mole-deg.)
KCl	9×10^{-4} to 2×10^{-2}	1·01 ± 0·04	$Ag^+ + Cl^- \rightleftharpoons AgCl(s)$	−18·9 ± 0·9	−14·9 ± 0·2	− 9·3 ± 2
KBr	1×10^{-3} to 2×10^{-2}	0·996 ± 0·03	$Ag^+ + Br^- \rightleftharpoons AgBr(s)$	−26·1 ± 0·7	−17·7§	−19·5
KI	3×10^{-4} to 2×10^{-2}	0·990 ± 0·03	$Ag^+ + I^- \rightleftharpoons AgI(s)$	−32·1 ± 1	−24·2§	−18·3
K_2CrO_4	2×10^{-3} to 6×10^{-2}	1·96 ± 0·03	$2Ag^+ + CrO_4^{--} \rightleftharpoons Ag_2CrO_4(s)$	−16·7 ± 0·5	−15·7 ± 0·4	− 2 ± 2

* Solvent: 43·1 mole per cent $LiKNO_3$—56·9 mole per cent KNO_3 eutectic melt.
† Precision expressed in terms of standard deviation of a single measurement.
‡ For precipitation processes indicated in column 4.
§ Data from ref. 3.

distinction, the entropy of precipitation of silver halides was normal, that is, corresponded to a loss of entropy upon precipitation, indicating that silver halide ions existed in the fused salt solution in a less-ordered state than in the solid phase.

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RADIATION CHEMISTRY

Chemical Effects of Ionizing Radiations on Nucleic Acids and Nucleoproteins

RECENT work[1] on the effects of ionizing radiations on nucleic acids (deoxyribonucleic and ribonucleic acids) in aqueous systems has shown quite clearly that the reactive species produced from the water attack mainly the constituent purine and pyrimidine bases and, to a lesser extent, the sugar moieties of these polynucleotide molecules. The extents of destruction of the individual bases on irradiation of deoxyribonucleic solutions (0·005 per cent) in the presence of oxygen (1 atm.) were measured and found to be as follows (G = molecules/100 eV.): $G(-\Delta\text{thymine}) = 0{\cdot}33$; $G(-\Delta\text{adenine}) = 0{\cdot}25$; $G(-\Delta\text{cytosine}) = 0{\cdot}23$; $G(-\Delta\text{guanine}) = 0{\cdot}18$. Breakage of the strands in the deoxyribonucleic acid helix is apparently mainly due to an attack of the radicals produced by irradiation on the sugar moieties, which leads to a splitting of the phosphate ester linkages along the chains. The extent of attack which leads to breakage of internucleotide bonds, leading to the production of phosphomonoester groups, has been determined directly with monophosphoesterase; the number of end-groups formed on irradiation with 200 kV. X-rays gives a yield of $G \simeq 0{\cdot}5$. Rupture of hydrogen bonds within the helix is a consequence of chemical changes in the polynucleotide chains; several hydrogen bonds can be broken following a single chemical event.

The hyperchromic effect which is observed in the action of the radiations on nucleic acids in solutions has been investigated in some detail. It has been concluded that this effect is caused, in general, by environmental changes of the chromophoric groups of the purine and pyrimidine bases of deoxyribonucleic acid, and is due to the change from the hydrogen bonding of the bases within the intact helix (where the bases of one strand are bonded to the bases of the complementary strand), to hydrogen bonding with water molecules when the latter have penetrated between the strands of the helix.

The chemical nature of the reactions induced by irradiation of nucleic acid has been studied in some detail by investigating solutions of the purine and pyrimidine bases and of the corresponding nucleosides and nucleotides[1].

Since deoxyribonucleic acid is generally found in biological systems in the form of nucleohistones or nucleoprotamines, a point of particular interest appeared to be a study of the changes induced by irradiation in deoxyribonucleic acid when combined with protein in the nucleoproteins.

Aqueous solutions of calf thymus nucleoprotein were prepared from fresh calf thymus glands by Doty and Zubay's method[2] using a Dounce homogenizer. Solutions ($\sim 0{\cdot}02$ per cent) were saturated with oxygen (1 atm.) for 15 min. prior to irradiation. The deoxyribonucleic acid used was kindly supplied by Prof. J. A. V. Butler. Calf thymus histone was obtained from the Mann Research Laboratories.

The irradiations were carried out with X-rays from a Victor 'Maximar' therapy tube operating at 200 kV. and 15 m.amp. Solutions were irradiated in 'Pyrex' glass vessels of the type previously described[3]. The dose-rate as determined by the Fricke dosimeter was 2,900 rads/min.

Experiments were carried out in which the total individual base compositions of irradiated and unirradiated nucleoprotein solutions were determined. For this purpose, samples were hydrolysed with formic acid and this was followed by chromatographic separation, using a butanol–ammonia system[4], and spectrophotometric estimation of the individual purines and pyrimidines. The results show quite clearly that up to doses of about $1{\cdot}3 \times 10^5$ rads, the bases of the nucleic acid were not detectably attacked by the radiation.

Another way of detecting any chemical modifications of the nucleic acid component involves determination of the rate of release of inorganic phosphate on hydrolysis at elevated temperatures[5]; this is rather a sensitive method, and has been successfully employed in irradiations of solutions of deoxyribonucleic acid. Solutions of nucleoprotein were irradiated, treated with catalase (to decompose hydrogen peroxide) and with chymotrypsin (to degrade protein) and then hydrolysed at 90° at *p*H 7·5. The rate of release of inorganic phosphate was almost exactly the same in the irradiated as in the unirradiated blank solutions. This latter result would therefore confirm that in the intact nucleoprotein no detectable attack on the polynucleotide takes place.

In contrast to these findings, it was found that on irradiation of solutions of synthetic mixtures of calf thymus deoxyribonucleic acid and histone, there was some degradation of the deoxyribonucleic acid component, but much less than in pure deoxyribonucleic acid solutions. In the synthetic mixtures, the protein protected the deoxyribonucleic acid to some extent, as would be expected from the fact that the free radicals produced by irradiation can distribute themselves between the nucleic acid and the protein.

We must conclude, therefore, that in the intact nucleoprotein as isolated from calf thymus glands, the active species produced by irradiation are unable to penetrate the protein sheath; apparently, up to doses as high as 10^5 rads practically all of them react with the protein and the deoxyribonucleic acid remains substantially undamaged. This chemical evidence is in agreement with the observation of Kaufmann *et al.*[6] that irradiation of nucleoprotein did not appreciably alter the viscosity of the deoxyribonucleic acid component.

These findings may explain the high radiosensitivity of the nucleus during certain stages of the mitotic cycle, when the protein is shed from the deoxyribonucleic acid.

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BIOPHYSICS

Electrostatic Measurement of the Geoelectric Effect in Coleoptiles

The so-called geoelectric potential, which develops between the upper and lower side of a plant when it is placed in a horizontal position, has been investigated by many workers[1–5] using different types of fluid electrodes which were applied directly to both sides of the plant. The original explanation of the cause of this potential given by Brauner[6] has lately proved to be unsatisfactory[7] and a new theory was proposed[8]. To test this theory it was necessary to carry out electric measurements on plants during much longer periods of time than has been done earlier. This was possible by using electrodes somewhat similar to those devised by Clark[5]. The results obtained by this method were difficult to reproduce and differed generally from those reported by earlier workers. During extensive measurements on *Avena* coleoptiles, *Pisum*, *Helianthus* and *Zea mays*, it was found that the results are often strongly influenced by the direct-contact electrodes. Therefore, it was thought necessary to measure these potentials without touching the plants at all, and to this end an entirely new measuring technique was developed.

This method makes use of the vibrating reed principle[9]. A thin plane gold electrode, 5 mm. × 10 mm., is placed at a distance of about 1 mm. from three to seven *Avena* or *Zea mays* coleoptiles placed in a row (see Fig. 1). This electrode is carefully insulated and is vibrated at a frequency of about 250 c./s.; it is earthed through a resistance R of 10^{10} ohms. If an electric field exists between the coleoptiles and the vibrating electrode, an alternating voltage will be generated across the resistance R. This voltage signal is applied to the grid of an electrometer tube connected as a cathode follower, and after further selective frequency amplification displayed on a cathode-ray tube screen. The other plate of the vibrating condenser is formed by the coleoptiles themselves. They are usually cut about 15 mm. from the apex and inserted into a 'Plexiglas' container P filled with tap water. With a miniature calomel electrode[10] in contact with this water reservoir, the potential of the coleoptiles can be varied at will by a variable voltage V (Fig. 1).

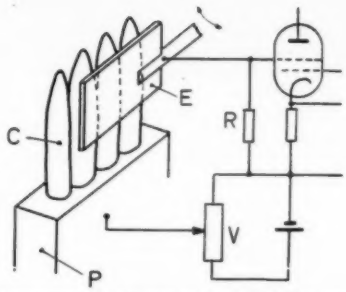

Fig. 1. Measurement of the geoelectric potential by means of the vibrating reed principle. This method permits the potential measurement with the vibrating electrode E without touching the coleoptiles C

The a.c. signal generated by the vibrating electrode E, which is displayed on the cathode-ray tube, is roughly proportional to the magnitude of the electric field between the coleoptiles C and the electrode E. Therefore, by adjusting the voltage V properly, the a.c. signal can be reduced to zero, thus indicating that the field-strength and the potential between the coleoptiles C and the electrode E is zero.

If, after this adjustment, the apparatus is placed in a horizontal position and a geoelectric potential appears on the surface of the coleoptiles, an a.c. signal is generated again because of the electric field due to this potential. By varying the voltage V, this signal can be reduced to zero again, the variation of V being roughly equal to the potential developed by the coleoptiles. Measuring this potential with the electrode E above and below the plants and applying a correction factor for the geometry of the coleoptiles, the true geoelectric potential can be found.

The results of such measurements, the reproducibility of which is definitely superior to the conven-

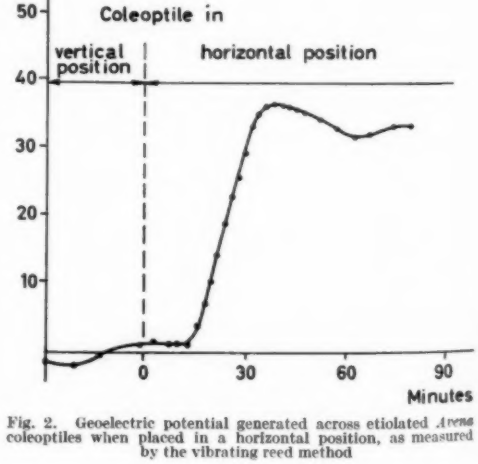

Fig. 2. Geoelectric potential generated across etiolated *Avena* coleoptiles when placed in a horizontal position, as measured by the vibrating reed method

tional method, are shown in Fig. 2. The measurements have been made on etiolated *Avena* and *Zea mays* coleoptiles in the dark. Contrary to previous results, the geoelectric voltage does not appear until 15 min. after tilting the plants into a horizontal position. This has been corroborated with *Avena*, *Pisum* and *Zea mays* by our extensive experiments with the conventional method using electrodes similar to the Clark type[5]. Further, the magnitude of the voltage is greater than that reported by the majority of previous authors. A more detailed description of the method and results with different plant materials will be published elsewhere.

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BIOCHEMISTRY

Screw Sense of the α-Helix in Poly-β-benzyl-L-aspartate

Blout and Karlson[1] have reported that the constant b_0 in Moffitt's equation for the dispersion of optical rotation[2] has values up to + 630° for solutions of poly-β-benzyl-L-aspartate in chloroform; the usual value for solutions containing α-helices of polypeptides is about − 600°, and corresponds to right-handed helices[3]. We have studied the dispersion of a number of copolymers of β-benzyl-L-aspartate with other amino-acids, and believe that the results demonstrate that the positive b_0 found for poly-β-benzyl-L-aspartate is due to a left-handed helix and not to an optical anomaly.

If we plot b_0 against composition for a series of random copolymers of β-benzyl-L-aspartate and γ-benzyl-L-glutamate, we find that although the values of b_0 for the two simple polymers are almost equal (though of opposite sign) the curve is very far from symmetrical. Eight mole per cent of L-glutamate is sufficient to reduce b_0 to zero[4], and more than 85 per cent of the total change in b_0 is produced by the addition of 15 mole per cent of L-glutamate; the effect of L-alanine residues is similar. These results are best explained by the hypothesis that the two simple polymers form α-helices of opposite screw senses, and that the preference of the L-aspartate residues for a left-hand helix is much less marked than that of the L-glutamate residues for a right-hand helix, so that comparatively few of the latter can dictate the sense. To explain these results on the basis of an optical anomaly we would have to postulate that this anomaly depends on long unbroken sequences of L-aspartate residues. However, other experiments show that the sequences of L-aspartate residues may be interrupted by either D-glutamate or D-aspartate residues with very little effect on b_0.

These conclusions are confirmed by measurements on a number of other copolymers, both random and block, and by building molecular models. A full account of this work will be published elsewhere.

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Isolation and Probable Functions of Betaine Esters in Brain Metabolism

In previous work, Hosein[1] reported that γ-butyrobetaine was found in extracts made from brain tissue of rats in convulsions which had been induced by intraperitoneal injections of cerebral convulsants. We have now found that fractionation of the gold precipitate formed from eluates of the chromatograms made from these extracts by the procedure of Linneweh[2] enables the identification of two other betaines. The melting points of the gold derivatives of the betaines obtained in this investigation are shown in Table 1 and compared with those obtained by Linneweh for synthetic betaines.

Table 1. MELTING POINTS OF GOLD DERIVATIVES OF VARIOUS BETAINES

Substance	Melting point (with decomposition) in deg. C	
	Linneweh	Betaine isolated
γ-Butyrobetaine	180–184	177–181
Crotonbetaine	212–214	209–211
Carnitine	150–153	149–153

From these results we conclude that the brain extracts from animals treated with cerebral convulsants contained free γ-butyrobetaine, crotonbetaine and carnitine.

Other work by Hosein[3] has shown that in normal brain extracts these betaines in the free form could not be detected. It was shown that the 'free' or immediately extractable acetylcholine from aqueous brain extracts (supernatant *A*) contained acetylcholine and propionylcholine, while the 'bound' fraction, released after chloroform treatment (supernatant *B*), contained, in addition to these choline esters, a mixture of the coenzyme A ester derivatives of the betaines mentioned above. These betaine esters were contained in a band of the chromatogram developed in the butanol/water system with an R_F between 0·45 and 0·56. The chromatogram pattern obtained from the 'bound' acetylcholine fraction in brain was similar to that obtained by Bannister *et al.*[4], who used ox spleen. We have synthesized enzymatically γ-butyrobetaine–coenzyme *A*, and this substance has an R_F of 0·55 in the butanol/water system. This thiol ester was found to possess acetylcholine-like properties similar to those obtained with eluates of the 0·45–0·56 band obtained from brain extracts. In both cases their physiological effects are abolished by atropine. Accordingly, it appeared from these

results that both the 'free' and 'bound' extractable acetylcholine from brain is not solely due to acetylcholine alone. The presence of the betaine–coenzyme *A* esters exclusively in the 'bound' acetylcholine fraction may accordingly be of significance in brain metabolism.

Other experiments by our group[5,6] and by others[7,8] have shown that ester derivatives of these betaines have acetylcholine-like properties, whereas the free (unesterified) betaines are inactive. Previously, Hosein and McLennan[6] described some pharmacological properties of the methyl ester of γ-butyrobetaine. In that paper γ-butyrobetaine was described as having these acetylcholine-like properties, but actually the methyl ester was used; this material was erroneously supplied to us as γ-butyrobetaine and accordingly it was used as such. We[1] have found that the methyl, ethyl and choline esters of γ-butyrobetaine are extremely powerful convulsants. Accordingly, it seemed possible that, *in vivo*, betaine esters could also be concerned with convulsive activity in brain, while the presence of the free betaines mentioned above could have been due to ester hydrolysis either *in vivo* or during the extraction process.

We have repeated our previous experiments, in which cerebral and spinal convulsants were injected intraperitoneally into rats, to determine whether betaine esters could be detected in the supernatant *A* fraction of the brain suspensions of these treated animals. The convulsants used were dieldrin, ammonium chloride, metrazol, picrotoxin, camphor and strychnine. In comparison experiments, cerebral convulsions were produced by electroshock. As before, all animals were killed during the convulsions and untreated animals served as controls. Examination of the chromatogram shown in Fig. 1 shows that, in addition to acetylcholine and propionylcholine normally present in supernatant *A*, when brain extracts made from animals treated with electro-shock or when cerebral convulsants were used, there was a band at R_F 0·45–0·56, which contained the betaine coenzyme *A* esters. This was not observed when strychnine was used. In normal animals this band was only found in supernatant *B*, that is, the tissue residue which had been treated with chloroform[3]. The presence of the betaine esters in the supernatant *A* fraction suggests that they were released from their normal cellular attachments by some action of the convulsive agents, and since they have been found to be indistinguishable from acetylcholine on assay preparations, they may be concerned with the initiation of the convulsions.

There are many indications that there may be several substances in brain other than acetylcholine which could have transmitter properties. The low choline acetylase activity and concentration of acetylcholine in the cerebellum are indicative of this[9,10]. Results of paper chromatographic analysis of chloroform-treated extracts, supernatant *B*, of the cerebellum and of the cerebral cortex of normal rats (see Fig. 2), have shown that the cerebellum contains a higher concentration of these betaine coenzyme *A* esters than does the cerebral cortex. This suggests that these betaine coenzyme *A* derivatives may function as transmitter substances in the cerebellum and perhaps also in other regions of the brain. An evaluation of the physiological properties of the coenzyme *A* ester derivatives of γ-butyrobetaine, crotonbetaine and carnitine is now in progress.

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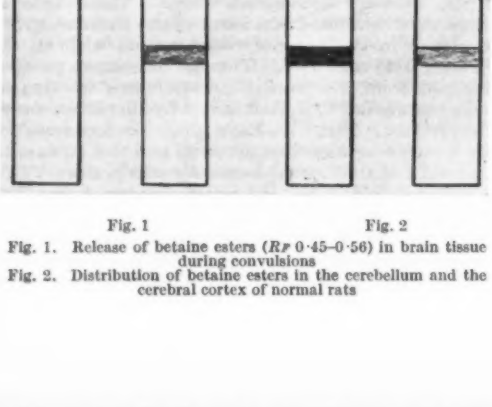

Fig. 1 Fig. 2

Fig. 1. Release of betaine esters (R_F 0·45–0·56) in brain tissue during convulsions

Fig. 2. Distribution of betaine esters in the cerebellum and the cerebral cortex of normal rats

Effect of Potassium Cyanide Poisoning on the γ-Aminobutyric Acid-Level in the Brain

Several substances, which affect brain metabolism, act upon the γ-aminobutyric acid-level in that organ[1]. Insulin-induced hypoglycæmia brings about a drop in the γ-aminobutyric acid-level, probably as a result of decreased glutamic acid concentration. The administration of some substances, known to inhibit glutamic acid decarboxylase, leads also to a drop in the level of γ-aminobutyric acid in the brain. Thus, semicarbazide, an inhibitor combining with the aldehyde group of pyridoxalphosphate, reduces the γ-aminobutyric acid-level in the brain by approximately 30 per cent[2]; in a similar way, 2-methyl-4-amino-5-oxymethylpyrimidine brings about a drop[3]. After the ethanol ingestion, however, the level of γ-aminobutyric acid content in the brain was found to be increased[4].

Potassium cyanide is a substance which inhibits the activity of glutamic acid decarboxylase, as has been shown by *in vitro* experiments by Wingo and Awapara[5]. This inspired me to follow the effect of cyanide poisoning on γ-aminobutyric acid in the brain.

Experiments were carried out on albino rats of Wistar *B* strain weighing 200–300 gm. Cyanide was administered intraperitoneally in the doses of 40 and

10 mgm./kgm. in 0·5 ml. After the stage of convulsions (1–4 min. following administration of potassium cyanide), the animals were decapitated. After weighing, the brain was homogenized in a homogenizer according to Potter and Elvehjem in 1 per cent picric acid solution. The homogenate was centrifuged, and the picric acid removed on a 'Zerolith *FF*' column. The brain extract thus treated was placed on chromatography paper Whatman 1 and submitted to electrophoretic partition in pyridin–acetate buffer at 26 V./cm. Electrophoretic partition and quantitative determinations of γ-aminobutyric acid and glutamic acid were made according to Wingo and Awapara[5], with the only difference that 0·5 per cent ninhydrin solution was prepared in aqueous acetone (90 ml. acetone + 10 ml. water), saturated with sodium carbonate. Optical density was measured on Zeiss spectrophotometer at 570 mμ.

Table 1

	No. of determinations	γ-Aminobutyric acid (μgm./gm. of wet weight)	*P*	Per cent
Control animals	25	303 (417–236)		100
Animals poisoned with potassium cyanide—40 mgm./kgm.	25	244 (339–186)	<0·01	80·5
Animals poisoned with potassium cyanide—10 mgm./kgm.	13	252 (341–189)	<0·01	83·0

As shown in Table 1, potassium cyanide poisoning causes a decrease of γ-aminobutyric acid by 19·5 or 17 per cent respectively.

When calculated for the dry weight of the brain of the control animals and of those poisoned with potassium cyanide, the concentrations in per cent were the same as given in Table 1.

After the administration of potassium cyanide the blood-level of γ-aminobutyric acid did not rise.

Table 2

	No. of determinations	Glutamic acid (μgm./gm. of wet weight)	*P*	Per cent
Control animals	14	1,855 (1,750–2,250)		100
Animals poisoned with 40 mgm. potassium cyanide/kgm.	14	2,130 (1,840–2,560)	<0·02	115
Animals poisoned with 10 mgm. potassium cyanide/kgm.	13	2,040 (1,720–2,620)	<0·05	110·5

Table 2 illustrates the changes of glutamic acid concentration in the brain following poisoning with potassium cyanide.

The decrease of concentration of γ-aminobutyric acid is probably due to inhibition of glutamic acid decarboxylase. This presumption is confirmed by the inhibition of glutamic acid decarboxylase *in vitro*, partly by a rise in glutamic acid concentration. In 1 gm. of wet tissue, there is a rise of 1·5–2·0 μ*M* in glutamic acid concentration. There is a drop of 0·5–0·6 μ*M* of γ-aminobutyric acid concentration, meanwhile.

The activity of the mechanisms of γ-aminobutyric acid degradation *in vitro* (transamination and oxidation) is relatively low. On the other hand, the rate at which changes in γ-aminobutyric acid-levels occur, following poisoning with potassium cyanide, indicates that this compound is intensely metabolized in the brain tissue *in vitro*.

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A New Method for the Differential Precipitation of Nucleic Acids from Aqueous Solutions

Many metallic ions are capable of reacting with sodium nucleates in aqueous solutions[1,2]. In these investigations, no attempt seems to have been made to differentiate between the reactivity of the two types of nucleic acid.

It has been found that the addition of an aqueous solution of indium chloride ($InCl_3$) to acetate-buffered solutions of highly polymerized nucleic acids in the presence of sodium chloride results in the formation of a precipitate containing indium and nucleic acid. This reaction, which does not seem to have been previously described, is a function of *p*H and ionic strength. By varying the ionic strength, it was possible to precipitate selectively either deoxyribonucleic acid or ribonucleic acid from aqueous solutions.

The quantitative precipitation of the two acids was carried out in a final volume of 5·0 ml. containing the following :

Deoxyribonucleic acid, prepared according to Kay *et al.* (ref. 3), 0·4 per cent in 0·14 *M* sodium chloride	0·5 ml.
Ribonucleic acid, prepared according to Crestfield *et al.* (ref. 4), 1·0 per cent in 0·14 *M* sodium chloride	0·5 ml.
Acetate buffer, 0·4 *M*, *p*H 5·0	0·5 ml.
Distilled water	3·0 ml.
Indium chloride, purchased from the Indium Corporation of America, Utica, N.Y., 0·05 *M* aqueous (freshly prepared)	0·5 ml.

After thorough mixing of these components, the solution is allowed to stand for 30 min. at room temperature and then centrifuged at 1,400*g* (International Laboratory Centrifuge) for 10 min. The supernatant solution contains only negligible quantities of material absorbing ultra-violet light at 260–280 mμ.

The optimal *p*H for the quantitative precipitation of the nucleic acids in the presence of 0·005 *M* indium chloride was established on the basis of experimental data shown in Fig. 1. In these experiments carried out separately with either deoxyribonucleic acid, ribonucleic acid or protein, the *p*H of the acetate buffer was varied over the range 2·9–5·8. The extent of precipitation of either nucleic acid, and for comparison bovine serum albumin (purchased from the Nutritional Biochemicals Corp., Cleveland, Ohio), was measured by determining the optical density of the supernatant solution at 260 mμ (nucleic acids) or 280 mμ (protein). Results for deoxyribonucleic acid and albumin were reproducible from one preparation to another. Ribonucleic acid was dialysed against 0·14 *M* sodium chloride at 4° C. for 48 hr. and if used immediately gave closely reproducible results. It should be emphasized that more than 95 per cent of

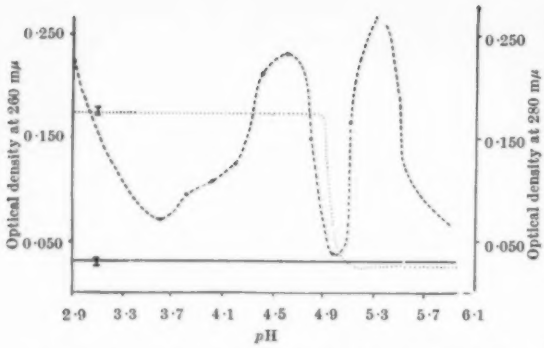

Fig. 1. Amounts of deoxyribonucleic and ribonucleic acids and bovine albumin remaining unprecipitated by indium at various *p*H levels and expressed as optical densities of the supernatant solutions as described in the text. Ribonucleic acid was dialysed against 0·14 *M* sodium chloride and used immediately after dialysis. ——, Deoxyribonucleic acid; – – – –, ribonucleic acid; . . . ., albumin

the ribonucleic acid in solution has been precipitated even at *p*H 5·3.

It was found that, by increasing the sodium chloride concentration to 4 *M* (other conditions remaining as described above), deoxyribonucleic acid remained in solution whereas ribonucleic acid under the same conditions was precipitated. Thus, after precipitation of ribonucleic acid at a final concentration of sodium chloride of 4 *M*, deoxyribonucleic acid remains in solution and, in turn, can be isolated by dialysis against buffered 0·14 *M* sodium chloride followed by addition of indium chloride to the dialysed solution. The two nucleic acids can be separated from a mixture quantitatively by this procedure.

This investigation, which was supported in part by a grant from the U.S. Atomic Energy Committee, will be reported elsewhere in detail, together with data on the isolation of pure nucleic acids from tissues.

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5-Hydroxytryptamine in Cerebrospinal Fluid

Although the 5-hydroxytryptamine content of human cerebrospinal fluid has been reported by Sachs[1] to increase after various head injuries or cerebral tumours, there appears to be no other reference in the literature to conditions resulting in an alteration in the content. While studying tuberculous meningitis in children, the opportunity arose for the cerebrospinal fluid to be tested for various amines including 5-hydroxytryptamine.

The cerebrospinal fluid was withdrawn from the patients using conventional methods, taking special care not to contaminate the samples with blood. The fluid was then tested either directly or after acetone extraction on the rat fundus preparation according to the method of Vane[2]. In 20 cases of tuberculous meningitis, the range of 5-hydroxytryptamine values was 0·2–3·0 μgm./ml., whereas in control children it was 0·03–0·1 μgm./ml. The more severe cases always showed high 5-hydroxytryptamine activity. Further, the clinical course of the disease closely followed the 5-hydroxytryptamine content of the cerebrospinal fluid. The significance of these findings is not yet clear.

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Viscosity of Concentrated Urea–Lithium Bromide Solutions

In the course of studies involving the physicochemical characterization of a proteolytic enzyme from a strain of *B. subtilis* (*NOVO* enzyme), viscosity measurements of the protein in concentrated urea and lithium bromide solutions were undertaken. For these studies, a 1 per cent solution of the protein was employed, and outflow times were measured at 20·0° in a modified Ostwald viscometer.

The results obtained in simple aqueous solution, 8 *M* urea and 7 *M* lithium bromide, are presented in Table 1. The significance of these results, in so far as characterization of the specific protein is concerned, will be discussed elsewhere (Geschwind and Ottesen, to be published). Of interest here are the outflow times found for the solvent, which is both 8 *M* with respect to urea and 7 *M* with respect to lithium bromide. Even in the absence of protein the outflow time for this solution is very great, as is shown in Table 1; the actual increment in outflow time above that found for water is approximately nine times greater than the sum of the individual increments for 8 *M* urea and 7 *M* lithium bromide. The outflow time is strikingly dependent upon the concentration of the two solutes, for as shown in the last line of Table 1, dilution of the solution by a factor of less than 8 per cent diminishes the outflow time by more than one-third. At the higher concentrations of urea and lithium bromide, the addition of protein to 1 per cent further increases the outflow time by approximately 150 sec.

Table 1

Solvent	Protein present	Outflow time (sec.)
Water	–	67·4
	+	69·0
8 *M* urea	–	99·2
	+	102·5
7 *M* lithium bromide	–	111·0
	+	122·5
8 *M* urea + 7 *M* lithium bromide	–	726
	+	874
7·4 *M* urea + 6·5 *M* lithium bromide	–	469

These results indicate that when both urea and lithium bromide are present in high concentrations in a solution marked interactions occur, and further, that the contribution of the protein in increasing the outflow time may be envisaged as arising from its effect on the solvent, rather than from an effect of the solvent on the protein. One type of interaction that might be involved is the formation of complexes of the general formula $LiBr.nCO(NH_2)_2$ (ref. 1). Another type of interaction is suggested by the claim that in strong urea solutions chain-like molecules form and collect together to give fibrils[2]. Such chains would arise from linear hydrogen-bonding, and the fibrils from lateral dipole–dipole interactions. On the basis of further experimental results, it was concluded that such fibrils are readily destroyed by the addition of dilute acetic acid to the strong urea solutions[2]. When the concentrated urea–lithium bromide solution employed here, however, was diluted with 1 *M* acetic acid rather than with water, to give a solution which is 7·4 *M* in urea and 6·5 *M* in lithium bromide (see last line of Table 1), no reduction in outflow time beyond that recorded for the solution diluted with water was observed.

If long fibrils do indeed form in 8 *M* urea solutions, their stability may be decidedly enhanced in the presence of concentrated lithium bromide by a mechanism (depression of the thermodynamic activity of water) similar to that proposed[3] for the stabilization by lithium bromide of hydrogen-bonding in proteins. If such a mechanism were operative, then the marked reduction in outflow time effected by dilution, as reported above, must arise from an inability of the long chains to form as readily in 7·4 *M* urea as in 8 *M* urea, rather than from the small difference in the activity of water in the two solutions.

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An Inverse Relation between the Liver Glycogen and the Blood Glucose in the Rat adapted to a Fat Diet

THE discovery by Claude Bernard[1] of the role of the liver glycogen in maintaining the blood sugar is well known. The liver was observed by Soskin *et al.*[2] to remove glucose from the blood when there was hyperglycæmia and to add it to the blood during hypoglycæmia. Later, the rate of uptake or output of glucose was shown to be directly proportional to the degree of the hyper- or hypo-glycæmia[3]. Recently an enzymic mass-action mechanism dependent on the effective intracellular concentration of hepatic glucose-6-phosphate has been put forward[4] to explain this regulation (the liver cells being freely permeable to glucose). However, while this mechanism may operate in animals adapted to the metabolism of glucose as the primary fuel, experiments in this laboratory have shown that in the rat adapted to a fat diet, the relationship between the liver glycogen and the blood glucose as outlined above is no longer evident.

Table 1. QUANTITY OF LIVER GLYCOGEN AND LEVEL OF BLOOD GLUCOSE IN RATS STARVED FOR 24 HR. THEN FED ON VARIOUS AMOUNTS OF BUTTER-FAT FOR FIVE DAYS

	Butter-fat fed (gm./day)				Normal fed controls
	2	4	5	6	
Liver glycogen (mgm./100 gm. of initial body-weight)	2·9 ± 0·9 (8)	25·1 ± 7·2 (8)	49·0 ± 6·8 (7)	63·7 ± 10·5 (10)	190·5 ± 11·6 (11)
Blood glucose (mgm./100 ml.)	64·4 ± 6·6 (8)	58·6 ± 4·8 (8)	55·1 ± 6·4 (6)	38·5 ± 4·0 (10)	79·4 ± 1·8 (14)

Values are the mean results ± the *S.E.* The number of animals is shown in parentheses.

Female albino rats (200 gm.), fasted for 24 hr. to reduce the liver glycogen to negligible amounts, were fed with 2, 4, 5 or 6 gm. of butter-fat per day. After five days on this diet, blood was taken from the tail for estimation of glucose[5], the animals were killed, and their liver glycogen content determined. The experimental procedures are described in greater detail in a previous publication[6]. The results (Table 1) show that the liver glycogen content rose proportionately to the quantity of fat fed per day ($P < 0·001$), confirming previous results[6]. On the other hand, as the daily intake of fat was increased so the blood glucose-level fell ($P = 0·001–0·01$), establishing an inverse relationship between the liver glycogen content and the blood glucose concentration ($P = 0·001–0·01$).

When the female rat, weighing 200 gm., is consuming 6 gm. of fat per day, the calorie requirement is satisfied and ketogenesis becomes reduced or absent[6]. The tissues must have become adapted to utilize an all-fat substrate, together with a small amount of endogenous protein. In view of the accumulation of liver glycogen, it is possible that one mechanism of adaptation is a conversion of fatty acids to carbohydrate precursors which are stored in the liver as glycogen and later released as glucose into the blood for transport to the tissues. However, since Soskin and Levine[7] have demonstrated that glucose uptake by the tissues varies directly with the blood sugar concentration, the foregoing explanation receives little support from the present observation of a marked hypoglycæmia, indicating that glucose utilization in the fat-adapted rat is much reduced. Increased insulin secretion would enhance glucose utilization in hypoglycæmia, but it is generally held to be low under conditions of carbohydrate deprivation[4]. Therefore, there is apparently no large-scale conversion of fatty acids to glucose involving transport of the glucose by the blood. The accumulation of liver glycogen can be accounted for satisfactorily by gluconeogenesis from endogenous protein and by the glycerol moiety of the fat molecule.

A more likely explanation of the mechanism of adaptation is that carbohydrate formed from non-carbohydrate sources is spared as catabolism of fat as a fuel is increased, permitting the liver glycogen content to rise. The mechanism for maintaining a normal blood glucose-level may become less active due to relative disuse of glucose by the tissues, thus allowing hypoglycæmia to develop. The condition may be compared to that prevailing in the normal

ruminant, in which a low blood sugar-level may be attributed to relative disuse of glucose as a fuel because of its replacement, or partial replacement, by the volatile fatty acids produced in ruminant digestion. Apparently, even in the non-ruminant animal, provided there is a suitable period of adaptation, brain tissue is able to survive in the presence of a very low blood sugar-level (several results as low as 25 mgm. per 100 ml. have been observed in these experiments).

It is clear that hypoglycæmia does not always stimulate glycogenolysis. If the maintenance of the blood sugar in the normal animal depends on an enzymic mass-action mechanism, then under conditions of fat adaptation where an inverse relation between liver glycogen and blood sugar concentration prevails, there must be a metabolic block in the conversion of glycogen to glucose in the liver. The possible nature of the block may be a reduction in activity of glucose-6-phosphatase, since hypoglycæmia in the presence of reserves of liver glycogen is characteristic of glycogen storage (von Gierke's) disease, in which there is a deficiency of glucose-6-phosphatase[8].

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Pterin Synthesis in the Amphibian Neural Crest Cell

A large amount of fluorescent substances of pterin type has been known to exist in the coloured skin of amphibians and they were shown to accumulate in chromatophores such as melanophores and xanthophores (allophores), as in the bull-frog[1]. During the development, pterins appear simultaneously with the pigmentation in chromatophores[2]. Moreover, certain substances of pterin type have been reported to accelerate the *in vitro* formation of Dopa-melanin[3,4]. These facts suggest an intimate relation between the pterins and pigment formation in chromatophores. To analyse such a relation, it is desirable to know where pterins are synthesized in the course of embryonic development. The present experiment was carried out to ascertain the capacity of pterin synthesis in the pro-pigment cells of urodelan embryos. Pterins were extracted with 70 per cent ethanol and chromatographed on paper using the following solvents: *n*-propanol/1 per cent ammonia (2 : 1), *n*-butanol/acetic acid/water (4 : 1 : 1) and 5 per cent acetic acid.

Pterin Fractions in the Middle Neurula and Larva. As a preliminary experiment, qualitative determinations were made of pterins in the neurula, where pigment cells had not yet differentiated, and in the larva, having well-developed melanophores and xanthophores in the trunk area. 30 intact middle neurulæ of *Hynobius nigrescens* (a salamander, Usui and Hamasaki's table, stage 17 [5]), 50 intact middle neurulæ of *Triturus pyrrhogaster* (a newt, Okada and Ichikawa's table, stage 18 [6]), trunk skins of 15 *Hynobius* larvæ at fore-limb-bud stage (stage 41–43), and 15 intact *Triturus* larvæ at fore-limb-bud stage (stage 37–38) were tested. Pterins were not found in the intact embryos at the middle neurula stage of either species, so naturally they were absent from the neural crest cells and the presumptive epidermis at that stage. At the fore-limb-bud stage, 2-amino-4-hydroxy-6-(1′,2′-dihydroxypropyl)-pteridine (biopterin[7]), 2-amino-4-hydroxypteridine, rhacophoro-jaune[8] (the same or similar with the 'sepia-pterine'[8] in *Drosophila*), *iso*xanthopterin, and 2-amino-4-hydroxypteridine-6-carboxylic acid occurred in both species. Of these five substances, rhacophoro-jaune and 2-amino-4-hydroxypteridine-6-carboxylic acid were found in abundance in both animals. In *Hynobius*, biopterin and *iso*xanthopterin were abundant, while there was only a small quantity of 2-amino-4-hydroxypteridine. In *Triturus*, on the contrary, biopterin, and especially *iso*xanthopterin, were much less, but 2-amino-4-hydroxypteridine was very abundant.

Pterin Synthesis in the Neural Crest Explant Enclosed in the Presumptive Epidermis. A small fragment of the trunk neural crest of the middle neurula was enclosed in the presumptive epidermis of the same embryo to ensure the sufficient differentiation of pigment cells. The epidermal explant without the neural crest served as a control. As a culture medium, Holtfreter's saline solution was used in order to avoid the additional complicating influences on pigmentation and pterin synthesis expected to occur in the explant. Each explant was cultured up to the stage where melanophores and xanthophores developed in the trunk region of the intact larvæ of the same breed (*Hynobius*, stage 41–43, 8 days at about 22°; *Triturus*, stage 37–38, 14 days at about 16°). 18–30 explants were used in each experiment. Whereas the explant with a neural crest had well-developed melanophores and xanthophores as in the intact embryos, the control epidermal explant was completely lacking in chromatophores. The fluorescent substances of pterin type were present in the former, and absent in the latter. Rhacophoro-jaune and 2-amino-4-hydroxypteridine-6-carboxylic acid were plentiful in both *Hynobius* and *Triturus* explants. Biopterin and *iso*xanthopterin were in much greater amount in *Hynobius*, and 2-amino-4-hydroxypteridine was abundant in *Triturus*. These quantitative relations of pterins in each explant were quite comparable with those found in intact larvæ of the respective species.

Hanging-drop Culture of Trunk Neural Crest. The pigmentation of chromatophores has been shown to be influenced by the surrounding epidermis in the field of experimental embryology. The synthesis of pterins in an explant, then, might be realized by the co-operation of epidermis, not by the pro-pigment cell itself. The fact that the epidermis had an indispensable role in the pterin formation was demonstrated in the following experiment. A small fragment of trunk neural crest of *Hynobius* middle neurula (stage 17) was cultured in Holtfreter's solution for 8–11 days at about 25° (stage 41–43 in controls). The melanophores and xanthophores in the explant showed little retardation as to the stage of pigmentation, but many of these pigmented poorly compared with those of the intact embryo. All kinds of

fluorescent substances found in the intact larva at that stage were detected in these explants, although no quantitative results were obtained.

These results indicated clearly that the fluorescent substances of pterin type found in the intact larvæ of *Hynobius* and *Triturus* were synthesized in the pro-pigment cells in the process of their differentiation. This may strongly suggest that the simultaneous appearance of the pigmentation and pterins during the chromatophore differentiation is an expression of the inseparable relation of the two. However, this does not necessarily mean that all pterins found in intact larvæ are formed in the pro-pigment cells during pigmentation. In fact, a very small but perceptible amount of fluorescent substances of pterin type is found usually in larval and adult tissues other than skin. Whether these small quantities of pterins are derived from pigment cells, or synthesized *in situ*, or even supplied by way of nutrition, remains to be settled.

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PHYSIOLOGY

Effect of Cortisone on Degenerating Nerve Fibres in Birds

THE observation that the usual appearance of the Marchi stage of Wallerian nerve fibre degeneration in experimental material is strikingly altered by cortisone acetate (Pfizer, Ltd.) led us to try to discover whether cortisone would also alter in any way the effects of tri*ortho*cresyl phosphate poisoning, which are usually most apparent in the myelin sheaths of nerve fibres. Our results so far seem encouraging. A single application of tri*ortho*cresyl phosphate painted on the combs of hens (the dose being 0·1 c.c. per kgm. body-weight) invariably causes general symptoms of intoxication and paralysis in the legs after 8–25 days[1]. The administration of 25 mgm. of cortisone by mouth three days before the application of tri*ortho*cresyl phosphate and further doses of 25 mgm. every third day thereafter in all cases prevented the onset of paralysis and reduced the other general symptoms. Even if the administration of cortisone was delayed until the hens were severely stricken by the poison, its beneficial effects were still apparent, for the general condition of the birds rapidly improved, they began to feed avidly, and the paralysis was reduced to a mild state of postural imbalance. Similar results were obtained if the dose of tri*ortho*cresyl phosphate was increased to 0·15 c.c./kgm.

In view of the outbreak of tri*ortho*cresyl phosphate poisoning in Morocco last year involving 10,000 people, these preliminary results may be of assistance in efforts to treat the crippled victims.

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Potentiation of Contractility in the Heart Muscle of the Rat and Some Other Mammals

THE steady-state amplitude of rhythmical myocardial contractions reached after the period of 'staircase' varies regularly with the frequency, following a typical curve in most animal species: it decreases at first, at very low frequencies, passes through a minimum (least favourable frequency), then at higher rates it increases up to a maximum (optimal frequency), to decrease again, at still higher rates, up to the limit of frequency which the preparation can follow[1]. The shape of the curve is, however, much modified in the rat in comparison with that of other species, the initial decrease of contractility being very marked, while the following increase to the optimum is, on the contrary, only small or absent[2]. In contrast to the classical staircase phenomenon, an inverted staircase (decrease of contraction) has been observed in the auricular or ventricular strips of the rat after a period of rest, or after the transition from a lower to a higher rate of stimulation[3].

These variations of contractility as a function of frequency may be interpreted as resulting from the interaction of two factors or effects, varying in opposite senses with the interval between the succeeding contractions[1]. One, namely, augmentation of amplitude on lengthening and diminution on shortening of preceding interval, has been called 'restitution'; the other, an augmenting effect on the shortening of the previous interval, has been termed 'potentiation' (Fig. 1). The 'potentiation' effect occurs only at short (least favourable) intervals, is cumulative and forms, in our interpretation, the common basis of the positive staircase, of the post-stimulation and post-extrasystolic potentiation, as well as of the steady-state amplitude variations. The terms 'restitution' and 'potentiation' are meant to be provisional, without any prejudice concerning the true nature of each of these effects, which may be dissociated and followed separately in their variation as a function of frequency[4] (Fig. 1).

The restitution effect may be measured by the change of amplitude in a number of single premature and delayed beats, intercalated in regular steady-state contractions. The 'potentiation' effect is indicated by the augmentation of the contraction next to the premature one (conditioning contraction), provided it follows at the basal interval. This point is very important, since in the case of an extra beat followed by a longer (compensatory) interval as well as in that of an intrapolated beat followed by a shorter interval, the change of contractility of the next contraction is due to both effects. The immediate return to the previous (basal) interval maintains, however, the 'restitution' effect constant, so that only a pure 'potentiation' effect appears. (For details of technique see our previous paper[4].)

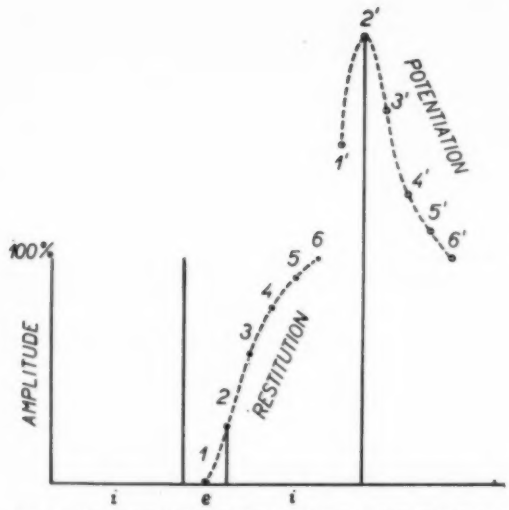

Fig. 1. Separate evolution of the 'restitution' and 'potentiation' effects. 100 per cent represents basal amplitude reached after a period of regular stimulation ; *i*, interval between successive regular stimuli ; *e*, interval of a premature beat conditioning potentiation of the next contraction. Amplitudes of premature beats following different pre-extrasystolic intervals 1–6 form a curve indicating the degree of restitution of contractility. Amplitudes of the respective post-extrasystolic beats 1'–6' form a typical curve of 'potentiation'. Left auricle of the dog, 30° C.; basal rate, 60 beats/min.

Comparison of results of experiments on 78 isolated left auricles of the dog (15), cat (3), rabbit (16), guinea pig (20) and rat (24) shows that : (1) the restitution effect has a markedly steeper course in the rat than in the other mammals examined ; (2) the potentiation effect in the rat myocardium is very small and occurs only when the premature beat is elicited at a very short interval (Fig. 2).

Also reactions of rat myocardium to some drugs (for example, strophantin) differ from those of other

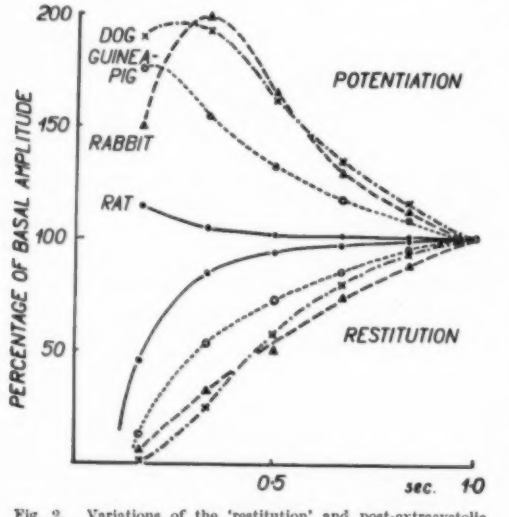

Fig. 2. Variations of the 'restitution' and post-extrasystolic potentiation effects as a function of the conditioning interval on the rat auricle compared with those of some other mammalian species. Values for the cat auricle, being very close to those of the guinea pig, have not been included. Individual experiments. Temperature, 30° C.; basal rate, 60 beats/min.

species[5]. Experiments on this matter are in progress in our laboratory and will be reported later.

The differences described in the behaviour of amplitude in relation to the interval between contractions show clearly that rat heart muscle cannot be considered as representative of mammalian myocardium, and no direct conclusions from experiments with it can be drawn for the physiology of contractility of the heart muscle of other mammals and especially man. The distinction and dissociation of two effects underlying the relationship of the rhythm to the contractile force may prove useful in the analysis of these complex but remarkably regular phenomena.

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Potassium Tolerance Tests in South Indian People

Potassium tolerance in man was studied by Zwemer and Truskowski[1] in relation to adrenal gland activity. After an oral intake of 20 mgm. of potassium chloride/kgm. body-weight, no rise of the plasma potassium-level is observed in normal Europeans, while a rise of 30 per cent or more is established in cases of cortical insufficiency. Accordingly, Henrotte (unpublished work) found a mean rise of 6 per cent in 12 healthy Belgian students. However, in Dakar, Leschi[2] obtained, in the same experimental conditions, an average of $4{\cdot}1 \pm 4{\cdot}8$ and $13 \pm 8{\cdot}1$ per cent, respectively, for the maximal rise in potassium of 6 Europeans and 32 Negroes of male sex. Consequently, I suggest the occurrence of a lower cortical metabolism in Negroes and its relation with the pigmentation.

Similar experiments have been undertaken in Madras with 26 Indians and 9 White Europeans or Americans, all male. The potassium tolerance tests were conducted according to Leschi's method[2], before breakfast and early in the morning, the room temperature being 29–32° C. (with 60–80 per cent humidity) throughout all the experiments. After the intake of potassium chloride, blood samples were taken every 20 min. for 1 hr. The potassium was determined in the plasma by flame spectophotometry. The maximal rise observed during the test and expressed in percentage of the fasting-level was as an average equal to $12{\cdot}4 \pm 7{\cdot}5$ per cent for White people and to $14{\cdot}3 \pm 7{\cdot}3$ for Indians. The differences between Indians, Africans and White people of Madras are not significant. In the case of the last-named, the maximum rise in potassium bears a direct relationship to the length of stay in Madras (Fig. 1), the relation being significant at the level of 5 per cent.

Our results indicate the occurrence of a climatic factor in the variation of tolerance of potassium in man, that is, of human cortex activity, rather than a racial factor. Our findings are confirmed by a fall of 27·3 per cent in 17-ketosteroid excretion observed

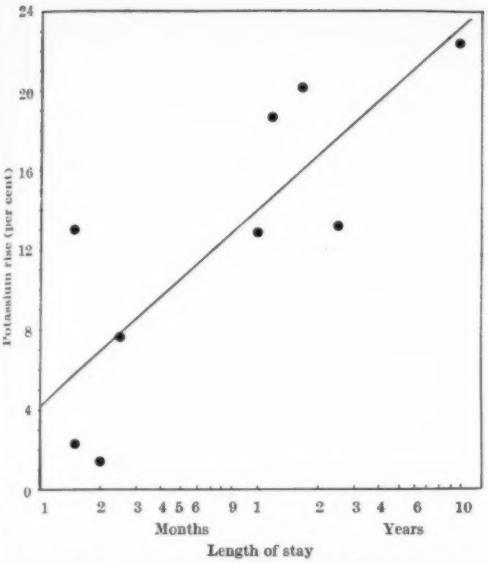

Fig. 1. Ordinate, maximal potassium rise observed during the test in White people and expressed in percentage of the fasting potassium-level; abscissa, length of stay in Madras expressed in months on a logarithmic scale

by Robinson *et al.*[3] during the hot season in Australian White people. On the contrary, urinary 17-ketosteroids determinations carried out in India[4] and in Africa[5] with both indigenous and Europeans show much larger values in Europeans than in the two melanodermic races. The discrepancy between these latter results and ours could be explained by the fact that urinary 17-ketosteroids represent the amount of cortical hormone excreted rather than the real activity of the gland. Relation between excretion of steroids and their amount in the blood could vary in the same conditions and should be further investigated.

We acknowledge with thanks the technical facilities provided for our work by Profs. K. P. Anandan and N. Verghese.

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Effect of the Cations of the Lyotropic Series on the Tension of Vascular Muscle

It has been found that, in experimental corticosteroid-induced hypertension, the content of potassium in the vascular wall increases according to the hypertension[1]. On the other hand, experiments *in vitro* with carotis strips showed that an increase of the potassium concentration of the bath solution causes a rise in tension which runs different from that of smooth muscle in the colon. The difference is due to the fact that potassium penetrates into the vascular muscle but not into the smooth muscle of the colon. In the vascular muscle the tension rises parallel to the intracellular potassium and remains constant as long as the latter is not diminished[2]. The relation between $[K]_e$ and the resting potential as well as between the resting potential and the change of length in muscle (contraction) are rather well known and will be discussed in another communication. There arises the problem of the effect of the intracellular potassium. The influence of other monovalent cations of the lyotropic series (cæsium, rubidium, sodium) on the tension of vascular muscle has been investigated, too, under the same conditions as the potassium effect. The results are illustrated in Figs. 1–3. They show: (1) The threshold concentration which induces a rise in tension of the vascular muscle increases with the diameter of the ion (cæsium, 5 mM; rubidium, 10 mM; potassium, 30 mM). To obtain an increase of the tension by means of sodium chloride, the sodium concentration of the Tyrode solution has to be augmented by 140 mM. At this concentration, the increase in tension can be effected merely by the high osmotic pressure, as it is in the case of sucrose, for example. (2) At equal concentrations of alkalichlorides, the increase in tension is smaller with increasing diameter of the ions (Fig. 3). (3) At higher cæsium concentration, the increase of tension is not continuous.

If the same concentration either of potassium or of cæsium is used, the amount of cæsium which penetrates into the vessel wall is only 42·5 per cent of the amount of the penetrating potassium. The fact that for cæsium the threshold concentration which causes

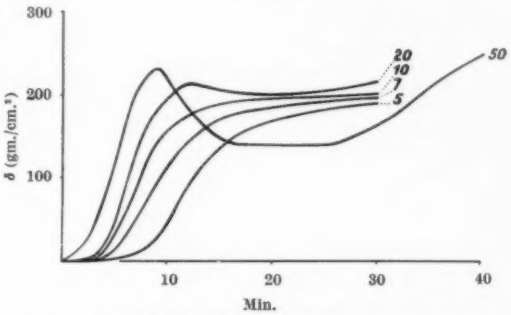

Fig. 1. Rise of tension with different concentrations of cæsium chloride. Figures on the right indicate mM cæsium. Initial tension, 310–335 gm./cm.²

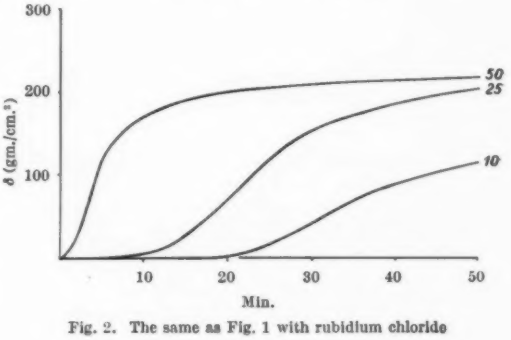

Fig. 2. The same as Fig. 1 with rubidium chloride

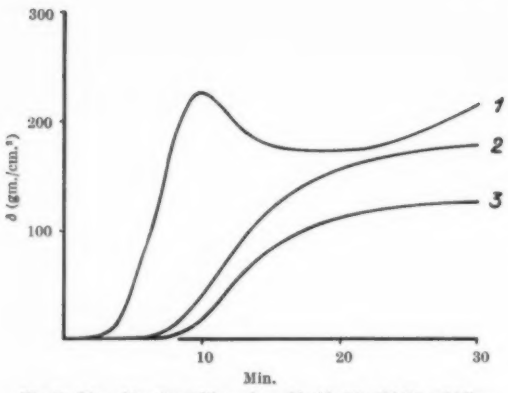

Fig. 3. Rise of tension with cæsium chloride 30 mM (1), rubidium chloride 30 mM (2), potassium chloride 30 mM (3). Initial tension 325 gm./cm.²

an increase of tension is of 5 mM only might be considered as especially interesting. Since the permeability constant for cæsium is smaller than for potassium and since the muscle fibre releases no potassium during the increase of the tension, contrary to what usually happens in contractures, we assume that the increase in tension is effected by the cæsium which penetrates into the muscle fibre. The rise in tension after the extracellular potassium has been increased as well as the recovering after it has been decreased take place in a medium free both of oxygen and of glucose. These results led us to the working hypothesis that the increase of tension is caused by the discharge of a protein anion by means of a lyotropic cation. As it is known, the smaller the diameter of the monovalent cation, the closer is its approach to the protein and the stronger its attraction. To evidence the same change of state of the protein, more potassium is used than cæsium (see threshold value). The tension is maintained by the new state of the protein, that is, without use of energy.

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Visco-elastic Behaviour of Blood Vessels of the Muscular Type

It was shown in the previous communication that the 'threshold-concentration' of ions of the lyotropic group which produce a rise in tension of the muscles in a vessel increases with increasing diameter of the lyotropic ion. Because this process also works in the absence of oxygen, we might assume that a discharge of protein ions takes place which causes a change of state. We presume that this change of state also produces a change in the visco-elastic behaviour.

The visco-elastic behaviour of ring-shaped or rectangular pieces of a cow carotis has been established with an oscillographic method using periodical stretches (frequency 1–1·8 cycles/sec.). The stress-strain relation (Young's modulus), as well as the phase shift between these, could be measured with a method described in an earlier publication[1] and now considerably improved. During the measurements, the samples of vessels were immersed in Tyrode's solution at body temperature. The questions treated were the following: (1) the influence of potassium (60–70 mM); (2) the influence of suprarenin; (3) the influence of electrical excitation on Young's modulus and on the viscosity constant η or its product $\omega\eta$ with the angular frequency, which can be computed from the phase shift between stress and strain and Young's modulus. The heat dissipated in the sample can then be found from $\omega\eta$.

(The heat generated by friction can be found as follows: the resistance to stretch for a piece of arterial wall of length l and cross-section q will be $R = \eta q/l$, where η is the viscosity constant. For a periodic stretch we might put $l = l_0 + \Delta l.\sin(\omega t)$. To overcome the friction, we need the force $F = R\ \mathrm{d}l/\mathrm{d}t$. The work done during a period is found by integration:

$$\int R.\frac{\mathrm{d}l}{\mathrm{d}t}.\mathrm{d}l = \pi.R.\omega(\Delta l)^2$$

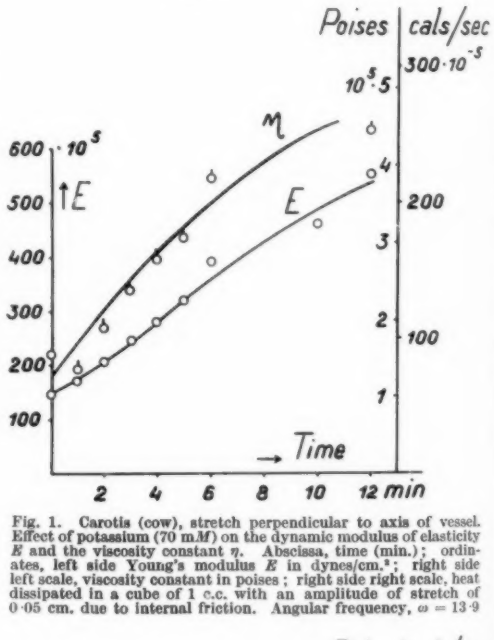

Fig. 1. Carotis (cow), stretch perpendicular to axis of vessel. Effect of potassium (70 mM) on the dynamic modulus of elasticity E and the viscosity constant η. Abscissa, time (min.); ordinates, left side Young's modulus E in dynes/cm.²; right side left scale, viscosity constant in poises; right side right scale, heat dissipated in a cube of 1 c.c. with an amplitude of stretch of 0·05 cm. due to internal friction. Angular frequency, $\omega = 13{\cdot}9$

Fig. 2. As with Fig. 1, carotis stretched in the direction of vessel's axis

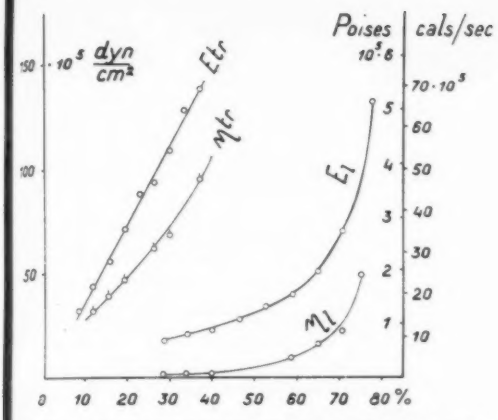

Fig. 3. Dynamic modulus of elasticity E_{tr} and viscosity η_{tr} in transversal, E_l and η_l in longitudinal direction as functions of relative stretch (cow carotis). External scale to the right gives the heat dissipated in a cube of 1 c.c. with an amplitude of stretch of 0·05 cm. due to internal friction. Angular frequency, $\omega = 6·5$

For the power we obtain $P = (\omega\eta).\omega(\Delta l)^2 q_l(2l)$. The product $\omega\eta_l$ is the quantity obtained by the experiment. It is of the same dimension as Young's modulus. In order to get a more concrete picture, we have calculated the heat generated in a cube of material of 1 c.c., where the amplitude Δl of stretch is taken to be 0·05 cm. For this specific assumption we obtain $H_{sp.} = (\omega^2\eta).0·298 \times 10^{-10}$ cal./sec.)

Potassium always brought about a considerable increase of tension and of Young's modulus perpendicular to the axis of the vessel, which reached their maximal value within a range of time of 12 min. after the administration of potassium. In some cases, according to [K] Young's modulus rose to about four times its original value and remained constant after this time. The internal energy dissipation increased in the same time.

If we carried out the same experiment with rectangular samples, one cut perpendicularly to, and the other in the direction of, the vessel's axis, we obtained an increase of Young's modulus from $1·5 \times 10^6$ to $5·5 \times 10^6$ dynes/cm.² in the first case (Fig. 1). η and the dissipated energy enhanced about at the same rate. Because only few muscle fibres run in the direction of the axis, we obtained in this direction an increase of Young's modulus only from $3·8 \times 10^6$ to $5·0 \times 10^6$ using the same initial stretch of 26 per cent (Fig. 2). The relative increase of the dissipated energy remained about the same as in the first case. In carrying out comparative measurements as mentioned here, care has to be taken that the experiments are performed with the same initial relative stretch, because the visco-elastic behaviour of vessels depends on it to a large extent. This we have illustrated with a set of experiments the results of which are given in Fig. 3.

When the immersion of 60–70 mM K was replaced by normal Tyrode's solution, the tension as well as Young's modulus dropped to the original value. Experiments with suprarenin and electrical excitation showed considerable increase in tension, but only a slight increase in Young's modulus. Skeletal muscle of frog (sartorius and musc. rect. abd.) showed no change in the visco-elastic behaviour either with potassium or with electrical excitation.

The importance of these results regarding the development of arterial tension in normal and in hypertensive individuals will be discussed in a further publication.

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Osmotic Regulation in the Larvæ of some Euryhaline Diptera

The relationship between blood concentration and the external medium is known in only one salt-water dipteran, the larva of *Aedes detritus*[1,2]. During a recent study of a small salt-marsh, on the Northumberland coast, several euryhaline Diptera were investigated with regard to survival and blood regulation in sea-water media. Some of the results are briefly reported here.

Groups of 10 larvæ of *Ephydra riparia* were kept in shallow dishes containing media ranging in concentration from tap-water to sea-water evaporated to half its original volume. Larvæ were not fed during the course of experiments at room temperature (18–22° C.).

In tap water, and concentrations less than normal sea-water all of the larvæ survived; several pupated, and adults emerged successfully during the course of the experiments. In concentrations greater than normal sea-water some of the larvæ lost water, became shrunken in appearance, and eventually died. The majority survived for at least two weeks in sea-water equivalent to 8·0 per cent sodium chloride.

Blood samples from individual larvæ were taken after 7 days for micro-chloride and freezing-point depression measurements. Both are powerfully regulated (Fig. 1*B*) to a greater extent than in *Aedes detritus* in concentrated sea-water media[1]. As in

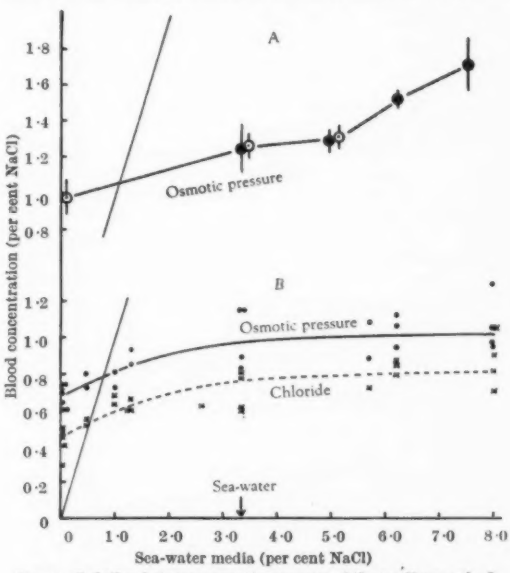

Fig. 1. Relation between osmotic pressure of the medium and of the blood in: *A*, *Cricotopus vitripennis*, typical form ● and var. *halophilus* ○, points mean of six larvæ, vertical lines extent of standard deviation; *B*, *Ephydra riparia*

Table 1. Osmotic Pressure of Body Fluids in Different Concentrations of Sea Water

Ephydra riparia			*Coelopa frigida*		
Osmotic pressure (sodium chloride, per cent)			Osmotic pressure (sodium chloride, per cent)		
Blood	Rectal fluid	Sea-water medium	Blood	Rectal fluid	Sea-water medium
0·80	0·91	0·46	1·02	0·27	0·0
0·72	1·01	0·46			
			0·75	2·00	1·70
			1·00	2·17	1·70
0·81	1·47	1·00			
			1·00	2·87	3·37
			1·02	3·44	3·37
1 15	4·83	3·37	1·01	3·20	3·37
			1·16	6·45	3·55
0·95	>10·0	8·02	1·10	3·73	3·55
1·05	>10·0	8·02	1·28	1·96	3·55
			—	3·13	3·55
			1·07	7·05	7·20
			1·07	7·40	7·20
			1·30	7·84	8·20

A. detritus the slight but gradual increase in blood osmotic pressure is due to an increase in blood chloride concentration, which is relatively high and accounts for approximately 75 per cent of the total blood concentration.

Similar observations were made on larvæ of two varieties of *Cricotopus vitripennis* (Fig. 1*A*). The estuarine form var. *halophilus*, obtained from the salt-marsh, completed its life-cycle in concentrations less than 5·0 per cent sodium chloride. In higher concentrations of sea water nearly all the larvæ became shrunken in appearance and died within 4 days. Larvæ of the typical form were obtained from coastal rock-pools at high water mark. These larvæ survived direct transference from tap-water into sea-water equivalent to 7·5 per cent sodium chloride, in which the life-cycle was completed, and they showed no signs of loss of water in this concentration of sea-water. These observations suggest that the two forms of *C. vitripennis* may be physiologically distinct, although each form is well adapted to survive the range of salinity normally encountered in its habitat.

The degree of osmotic independence shown by larvæ of *A. detritus*, *E. riparia* and *C. vitripennis* can probably be achieved only by a considerable degree of impermeability to water and salts, and it is significant that they do not possess functional anal papillæ, which are characteristic of aquatic dipterous larvæ. Intake of salt-water through the gut is, however, likely to occur, and the larvæ must then elaborate a fluid in the rectum at least as concentrated as the external medium. Preliminary measurements of the freezing-point depression of rectal fluid obtained from larvæ of *E. riparia* show that this species can elaborate fluid considerably more concentrated than the medium (Table 1). Similar measurements were also made on larvæ of *Coelopa frigida* (Table 1), which live in wrack beds stranded at high tide-level. As in *A. detritus*[2], the ability of *C. frigida* to elaborate a fluid hyper-osmotic to the medium is not so well developed as in larvæ of *E. riparia*.

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HÆMATOLOGY

Immuno-electrophoretic Demonstration of Precipitating Components in Sera from Pregnant Women

Smithies[1] and also Thornes[2] recently described the occurrence of certain serum proteins in sera from pregnant or recently pregnant women. According to Smithies[1], an α_2-globulin is present in sera from about 10 per cent of women in late pregnancy or shortly after delivery, and is demonstrable by means of starch-gel electrophoresis. Thornes[2], by means of gel-diffusion experiments, demonstrated serologically specific components in pregnancy sera by absorbing the immune serum prepared in rabbits with normal human serum. In each of 29 sera collected from patients during the last three months of pregnancy, he found this serologically distinct component. Immunization of rabbits with placental extracts made possible the demonstration of one to four different antigens serologically different from the serum proteins of normal sera, two of which were also found in sera from patients with abnormal tissue metabolism.

In order to study the possible occurrence of 'pregnancy-specific components', an antihuman immune serum, prepared in rabbits by immunizing with serum from patently normal blood donors, was absorbed with serum from one such blood donor by means of the intra-basin-gel absorption[3,4], and used to develop the immunoelectrophoretic pattern of sera from 7 women taken immediately after normal delivery. In five of these sera a precipitate in the fast α_2-globulin region was demonstrable (precipitate *A*). In two of these five sera also another precipitate (precipitate *B*) appeared in the slow α_2-β_1-globulin region.

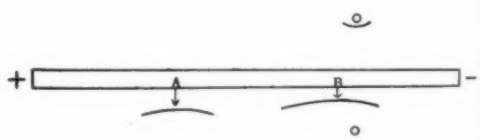

Fig. 1. Diagrammatic representation of presumed *C*-reactive protein precipitate (upper basin) and the 'pregnancy precipitates *A* and *B*' (lower basin) in immunoelectrophoresis

It was also found that some normal sera prevented the appearance of precipitates *A* and *B* or one of these components when used to absorb the immune serum in the intra-basin-gel absorption technique. This property of normal sera appears to be constant in the same individual for at least one year.

Sera from 20 normal subjects (males and females) and sera from 3 of 4 patients with diseases involving 'tissue destruction' did not give any precipitates against absorbed immune serum. The serum of one of these 4 patients did, however, give precipitate *A*. This serum also formed a precipitate against a commercially available *C*-reactive protein immune serum (Schieffelin, New York) in immunoelectrophoresis. This presumed *C*-reactive protein precipitate differed from the precipitates *A* and *B* in that it occupied different electrophoretic and diffusion positions, and its shape was different. The two pregnancy sera possessing both precipitates *A* and *B* did not show precipitate formation against *C*-reactive protein immune serum.

In conclusion, it can be stated that certain anti-human immune sera absorbed with selected normal

sera give two electrophoretically different precipitates with some sera from recently pregnant women. Other 'pregnancy sera' when examined by the present technique[3] lack either both or one of these precipitates.

Precipitate formation between selected 'pregnancy sera' and absorbed immune serum will also distinguish between four types of normal sera, by their capacity of completely inhibiting the formation of visible precipitate, by inhibiting only one of these precipitates but not the other and finally by not inhibiting the formation of any of these 'pregnancy precipitates', when used as absorbing reactants of the immune serum.

We gratefully acknowledge the liberal supply of sera from the Department of Women's Diseases, Sabbatsberg Hospital, Stockholm.

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Sickling Phenomenon in Deer

GULLIVER[1] described peculiarly shaped red cells in deer blood and Undritz[2] was able to produce these cells *in vitro* by passing oxygen through the blood. The cells looked remarkably like human sickle-cells. Gulliver examined three tropical deer: *Cervus mexicanus*, *Cervus reevesii* and *Cervus porcinus*. He also mentions a Persian deer, but its scientific name is not given. O'Rouke[3] investigated 178 deer in the United States and found 'sickle-cells' in 14. Undritz obtained positive results with the blood of *Cervus elaphus*, *Dama dama*, *Sambar* (*Rusa*), *Pseudaxis sika*, *Pseudaxis hortulorum*, *Axis axis*. The present investigation has been carried out with blood from *Elaphurus davidianus* (Père David deer). No sickle-cells could be produced with the blood of *Rangifer tarandus* (reindeer), *Alces alces* (elk), and *Cervus canadiensis* (Wapiti deer).

In man, sickle-cells are produced when erythrocytes containing the abnormal hæmoglobin *S* are deoxygenated. This hæmoglobin is relatively insoluble in the reduced state and on deoxygenation it forms intracellular tactoids which stretch the cell envelope and give the cell its bizarre sickle shape. It might seem that in the deer the effect is just the opposite, particularly because the sickling produced by treatment with oxygen can be reversed by addition of the reducing agents $NaHSO_3$ and $Na_2S_2O_4$. However, we can now report that sickling of deer cells occurs equally well when the blood is saturated with nitrogen or carbon monoxide but not with carbon dioxide. The effect of oxygen, nitrogen and carbon

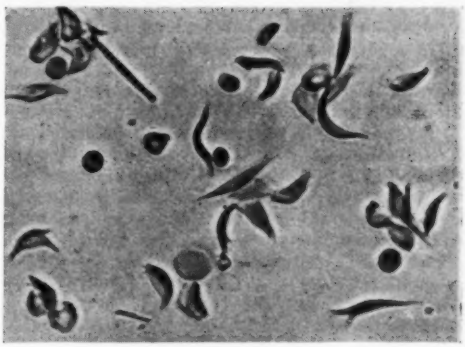

Fig. 1. Red cells of *Elaphurus davidianus* (Père David Deer) at *p*H 7·8. (× 750). Heparinized blood was mixed with an equal volume of 0·1 *N* Sørensen phosphate buffer *p*H 7·8 and the mixture was saturated with carbon monoxide

monoxide is due to a replacement of the carbon dioxide which causes as it were a 'respiratory alkalosis'. The reducing agents are acid, and hence they reverse the alkaline *p*H and the sickling.

When deer cells are suspended in 0·1 *N* KH_2PO_4, no sickling can be produced by gassing with oxygen, and when they are suspended in 0·1 *N* Na_2HPO_4 they sickle without any further treatment. There is a relatively sharp transition from the normal to the sickle-shape between *p*H 7·0 and *p*H 7·5; some sickle-cells can already be noted at *p*H 7·2 and nearly all cells are sickled at *p*H 7·4.

When the solubilities of oxygen, of reduced and of carbon monoxide hæmoglobin are compared, they

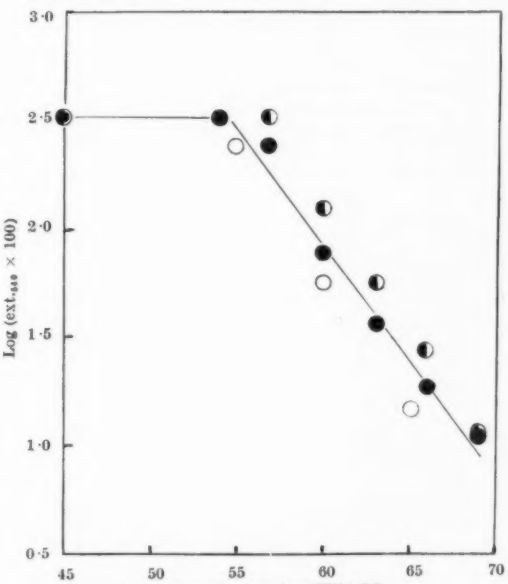

Fig. 2. Solubility in ammonium sulphate solutions of oxyhæmoglobin (○), reduced hæmoglobin (●) and carboxyhæmoglobin (◐) of *Elaphurus davidianus* (Père David Deer). To 9·5 ml. $(NH_4)_2SO_4$ solution of increasing saturation were added 0·5 ml. 0·5 per cent deer hæmoglobin. Reduced hæmoglobin was produced by addition of 30 mgm. $Na_2S_2O_4$. After mixing, the 10 ml. samples were kept in a stoppered vessel for several hours at 23·5° C. and then filtered. The hæmoglobin filtrate was converted into cyanmethæmoglobin and measured colorimetrically. It will be seen that there is no significant difference in solubility of the three hæmoglobins

are seen to differ little, and indeed Fig. 2 shows that the values for reduced deer hæmoglobin lie between those for oxygen and carbon monoxide hæmoglobin.

There is no significant difference in the solubility at increasing concentrations of phosphate buffers of *p*H 7 and *p*H 8. It was noticeable in these tests as well as in those described in Fig. 2 that precipitated oxyhæmoglobin which was left on the filter paper after filtration was rapidly transformed into methæmoglobin, whereas this was not so in the case of the human hæmoglobin controls. Deer hæmoglobin is oxidized by $K_3Fe(CN)_6$ about twice as fast as human hæmoglobin.

We wish to thank Dr. E. Lang, director of the Basle Zoo, for kindly supplying the deer blood.

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Platelet-Count Differences in Blood of the Rabbit Right and Left Heart Ventricles

This work was undertaken in an attempt to determine whether a difference could be demonstrated in the platelet counts of the blood of the rabbit right and left heart ventricles. That such a difference might occur suggested itself from the recent work of Sharnoff and Kim[1,2], which studies revealed that megakaryocytes are present normally in the lung blood vessels of all mammals, where they appear to break up in the pulmonary capillary anastomoses into platelets. Therefore, it was postulated that if the lung vessels were a possible site of platelet formation, the blood of the left heart ventricle could contain a higher number of platelets than that of the right ventricle. The difference in number of platelets, it was believed, would depend only on the number of megakaryocytes present and breaking up at any one time in the lung vessels.

Twenty young female Belgian hares weighing 2–4 lb. were killed by rapid air embolism and within 1 min. the chest cavity was opened and the heart exposed. Blood samples were obtained by needle aspiration from both ventricles while the heart was still in ventricular flutter. The blood was preserved with 'Versene' (disodium salt of ethylenedinitrotetraacetic acid, Eastman-Kodak). Indirect platelet counts were performed in duplicate by Fonio's method and averaged. Erythrocytes were determined by the counting chamber method. The animals were raised and maintained under outdoor conditions and temperatures except for short periods when unheated housing was provided. The work was begun in August 1958 and completed in February 1959. On this basis the animals could be divided into two equal groups of 10 each. The first group of 10 was studied during warm and mild autumn weather. The second group was studied during the winter months. For convenience the groups are designated accordingly as summer and winter animals.

A striking difference in platelet counts of the blood of the right and left ventricles was noted with two exceptions in the winter animals. No essential difference was found in the platelet counts of the blood of both ventricles of the summer animals and in the two exceptions of the winter animals. The winter animals, including the two exceptions, revealed the platelet counts of the right ventricle averaging 245,000 per cm.^{3}, while the left ventricle blood revealed platelet counts averaging 408,000 per cm.^{3}. Average platelet counts of the right and left ventricle bloods of the summer animals were respectively 256,000 and 254,000 per cm.^{3} (Fig. 1). Erythrocyte counts of the 20 animals averaged 5·4 million per cm.^{3}.

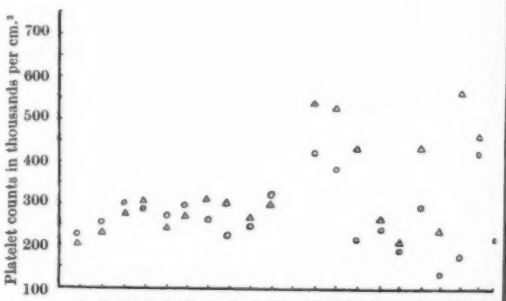

Fig. 1. △, Left ventricle; ○, right ventricle. 1–10, Summer animals; 11–20, winter animals

These studies indicate that from the lung vascular system there is added to the blood of the winter animals a significant number of platelets. This would tend to substantiate the earlier suggestion of Sharnoff and Kim[1] that the lung vessels may be a significant site of platelet formation. The significant increase of platelets in the winter animals in this study also complements the observation by Sharnoff and Kim[2] in an earlier study where significantly high numbers of platelets were observed in the peripheral blood of winter control animals compared to summer control animals.

It is suggested that the source of the increased platelets are the pulmonary megakaryocytes usually present in the lung vessels. It is also suggested that the stress of winter cold may stimulate an increase in number of pulmonary megakaryocytes which on the further stress of killing the animals break up rapidly into platelets. It may also be postulated that where no significant increase in platelets occurs the lung vessels may have a low number of megakaryocytes.

This work also corroborates earlier findings that the lungs may be a source of platelets. Howell and Donahue[3] in dog lung perfusion studies, and later Bierman[4] in human studies, recorded such evidence. In this report, however, a more rational explanation of this phenomenon is presented. This is further supported by the histological observations of Sharnoff[5] revealing that the pulmonary megakaryocytes are moulded and broken asunder in the pulmonary capillaries and their anastomoses and thus emerge as

casts of the capillaries and at times, therefore, appear in the peripheral blood as long platelets.

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PATHOLOGY

Absence of Local Cytotoxic Change in Man from Griseofulvin

With the importance of griseofulvin in the treatment of superficial fungous infections, it is imperative to know more about the toxic reactions especially if treatment is prolonged. Since the significant studies of Paget and Walpole[1] on the interference with mitosis under massive parenteral administration of griseofulvin in rats, there has been continued interest in investigations of this phase of reaction in man. Our purpose was to develop a technique for studying possible local cytotoxic reactions in man from locally deposited griseofulvin.

Supersaturated solutions of microcrystalline griseofulvin were prepared in saline, sterilized by autoclaving, and after vigorous agitation, 0·1–0·2 ml. was injected into 14 patients into areas of normal skin of the back and arm and into the scalp in the occiput area. In many instances the injection site was tatooed with indian ink to localize the crystal mass. Controls had been done previously with indian ink particles. In addition, in 6 patients, griseofulvin was injected into three basal cell tumours, one squamous malignancy, one melanoma and one malignant lymphoma. In four additional subjects, a lotion containing 1 per cent griseofulvin was rubbed daily for three weeks into basal cell carcinoma, squamous cell carcinoma, and into the so-called precancerous senile keratosis. To detect any anti-inflammatory activity of griseofulvin, saline suspensions of griseofulvin were injected repeatedly into spots of psoriasis, and neurodermatitis.

No local anti-inflammatory property could be detected. In normal skin, the biopsies were taken at intervals ranging from 1 hr. to three months after local injection and were studied in frozen section and in prepared sections with routine hæmatoxylin–eosin, toluidine blue *p*H 6, periodic acid–Schiff, Feulgen stains. The frozen sections were examined under the polarizing microscope to detect the depots in the dermis of the insoluble crystals. After a period of several days, crystals could not be detected under the polarizing microscope. In three instances, a bioassay of the skin extract was performed to detect antifungal activity of the tissue. In all these experiments, there were no spectrofluorometric determinations for griseofulvin in extracts of the injected skin. A total of 30 injections of griseofulvin was given.

In brief, there was only occasionally a mild foreign-body reaction of non-specific type about the depot of crystals. This subsided rapidly, usually within three or four days, and then no demonstrable inflammatory activity could be detected except occasional perivascular lymphocytic infiltrate. In one patient, after three weeks there were still a few histiocytes and foreign-body giant cells. There was no change in mitosis in any portion of the epidermis surrounding this, or in any portion of the adjacent hair follicle. In only one experiment, vacuolization of the cells in the adjacent portion of the hair follicle was found. In one instance, three months after injection, no change was found. In all the human tumour experiments there was no effect in either retardation or acceleration of the tumour growth, nor any demonstrable local effect on the individual tumour cell. In clinical observation[2] of a year's experience with oral griseofulvin in fungous therapy programme on more than 400 patients, there has been no evidence of any effect upon associated skin tumours, including basal cell, squamous cell and melanomas. In two patients with melanomas, griseofulvin was given in dosages of 2–4 gm. There is no information available on the effect on any associated internal visceral tumours other than the melanomas.

To amplify this study in the Department, the effect of griseofulvin in animal tumour experiments was initiated.

Griseofulvin crystals were furnished by Dr. G. Kenneth Hawkins, Clinical Research Division, Schering Corporation, Bloomfield, New Jersey.

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Tumour-promoting Effect of Excessively Large Doses of Oral Griseofulvin on Tumours induced in Mice by Methylcholanthrene

Large intravenous doses of griseofulvin in rats have been found to arrest mitosis in metaphase in certain organs, for example, bone marrow, seminal epithelium and intestinal epithelium. We postulated that since griseofulvin taken orally is soon found in the keratin layer of the skin, there might be an antimitotic effect with a delay in the production, and a reduction in the number, of tumours that would be produced by applications of methylcholanthrene to the epidermis of mice. A pilot experiment was performed which gave quite unexpected results.

White Swiss male mice of 24–28 gm. per mouse were divided into five groups. One drop of 0·5 per cent 3-methylcholanthrene in acetone was applied twice weekly for 4 weeks to the lower back of the mice of groups 1, 2 and 3.

Group 1 consisted of 20 mice receiving standard mouse food and having applications of methylcholanthrene. None of the 20 mice had any tumours formed as late as 12 weeks after the start of methylcholanthrene applications.

Group 2 consisted of 10 mice receiving a 1 per cent griseofulvin mouse food mixture for 6 weeks prior to, during and after the applications of methylcholanthrene. This group showed 5 of the 10 mice to have papillomas formed at the end of the first month of applications of methylcholanthrene. By the end of the second month of the experiment, 6 of

10 mice had tumours formed, and in several cases multiple tumours were seen. A few of these tumour growths were biopsied at the ninth week of the experiment and showed extraordinary hyperkeratosis and much mitotic activity. One was judged to be premalignant.

Group 3 consisted of 10 mice receiving 0·5 per cent griseofulvin mouse food mixture for 6 weeks prior to, during and after the applications of methylcholanthrene. At the end of a month, one of 10 mice showed a neoplasm which was biopsied at the ninth week and proved to be a well-differentiated epidermoid carcinoma. At the end of two months, 2 of 10 mice had tumour growths.

Group 4 consisted of 10 mice receiving a 1 per cent griseofulvin food mixture as long as group 2, and group 5 consisted of 10 mice receiving a 0·5 per cent griseofulvin food mixture as long as group 3. No methylcholanthrene was applied to these groups. No tumour growths have appeared in groups 4 and 5, which have received griseofulvin for 18 weeks.

We are repeating this experiment in larger groups of animals at the present time, and at the sixth week of the new experiment find that we are obtaining similar results. An addition to the experiment showed no tumours to have formed in mice receiving either a 0·01 per cent or a 0·1 per cent griseofulvin food mixture and having methylcholanthrene applications twice weekly for 6 weeks.

It is emphasized that the dosage used in the 1 per cent experiments was approximately 100 times that used in man.

This experiment was sponsored through the United States National Institutes of Health, Division of Research Grant *CY*-5071 (*A*). Griseofulvin powder was obtained from Dr. Clarence Denton, Division of Clinical Investigation, McNeil Laboratories, Inc., and Dr. G. Kenneth Hawkins, Clinical Research Division, Schering Corporation.

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ANATOMY

Presence of a Pituitary Portal System in Elasmobranchs

Since the discovery in the 1930's of the pituitary portal system in man, a similar system has been described in a large number of vertebrates, from amphibians to mammals[1]. Green did not notice a portal system in fishes, but suggests that the large sinusoids lying between the neurohypophysis and pars intermedia might serve a similar function, namely, a neurovascular contact involved in the control of the adenohypophysis.

The present investigations of the pituitary vascular system of some elasmobranchs (*Scyllium canicula*, *Squalus acanthias*, *Raja batis* and *Raja radiata*) have shown the presence of a definite portal system in these species. It consists of a primary plexus on the ventral surface of the hypothalamus, portal vessels running along a kind of infundibular stem to the neuro-intermediate lobe, the sinusoids of which thus make up the secondary plexus. From the primary plexus, more or less extensive portal vessels may also open into the sinusoids of the anterior lobe, thus resembling conditions in the tetrapods.

In *Scyllium canicula*, the median hypothalamic floor between the inferior lobes is modified to a kind of median eminence. This is covered with the capillaries of the primary plexus, and the anterior lobe of the adenohypophysis attaches to its median surface.

This part of the hypothalamus is very similar to the median eminence of higher vertebrates, partly because of its vascularization and contact with the adenohypophysis, but also in other details. The fibre layer under the ependyma thus contains the tractus preoptico-hypophyseus, and outside this is a zone with only scattered nerve fibres. The capillaries of the primary plexus are buried in furrows on the surface of this outer zone. The furrows are most distinct laterally; along the median part, which is in contact with the anterior lobe, the capillaries are of a simpler type.

From the primary plexus, portal vessels run backwards along the thin ventricular floor behind the inferior lobes, and enter the neuro-intermediate lobe (Fig. 1). Most of the blood enters the large sinuses between the thin 'neural lobe' and the cell cords of the pars intermedia. From these sinuses smaller vessels branch through the remainder of the neuro-intermediate lobe. A few portal vessels run from the anterior part of the primary plexus to the sinusoids of the anterior lobe.

Besides the portal system, which is median, there is also a lateral venous supply to the neuro-intermediate lobe: on either side a large vein, collecting blood from the diencephalon and anterior mesencephalon, enters the lobe[2]. Part of these veins can be seen in Fig. 1.

The arterial supply is small; there are no distinct arteries to the adenohypophysis, although small

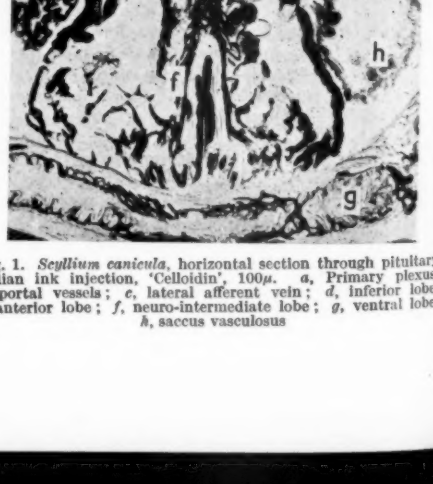

Fig. 1. *Scyllium canicula*, horizontal section through pituitary. Indian ink injection, 'Celloidin', 100μ. *a*, Primary plexus; *b*, portal vessels; *c*, lateral afferent vein; *d*, inferior lobe; *e*, anterior lobe; *f*, neuro-intermediate lobe; *g*, ventral lobe; *h*, saccus vasculosus

vessels reach its margins. Thus, small arteries run along the inferior lobes, close to either side of the anterior lobe, supplying mainly the primary plexus, with no observable direct branches to the anterior lobe. There are also arteries to the posterior part of the infundibulum; they probably give a small arterial contribution to the neuro-intermediate lobe and saccus vasculosus.

The gland is drained by a short venous trunk at the posterior ventral aspect of the neuro-intermediate lobe. It enters the large transversal sinus interorbitalis.

In *Squalus acanthias* the primary plexus is less distinct and most of the portal vessels enter the anterior lobe; only a small number run caudally to the neuro-intermediate lobe. Lateral afferent veins and a ventral drainage are also present in this species.

In *Raja batis* and *R. radiata* the ventricular floor behind the inferior lobes is very much expanded laterally and is covered by a dense system of parallel, longitudinal portal vessels. They enter the neuro-intermediate lobe in a manner similar to that of *Scyllium canicula*. Lateral afferent veins appear to be absent in *Raja*, but there is a large ventral vein draining the gland, running along the interhypophysial peduncle. Both *Raja* and *Squalus* have distinct arteries to the neuro-intermediate lobe.

In view of the constant occurrence of the pituitary portal system in the tetrapods, it is interesting to find a similar system also among the elasmobranchs. A noticeable difference is that in *Scyllium* and *Raja* most of the portal vessels enter the neuro-intermediate lobe, with only minor connexions with the anterior lobe. In higher vertebrates the portal vessels invariably run to the pars distalis, and appear to be the only or main vascular supply to this part of the pituitary.

The presence of a pituitary portal system and a distinct median eminence in elasmobranchs makes it necessary to modify earlier opinions on the phylogenetical derivation of the tetrapod neurohypophysis[3]. The differentiation of the neurohypophysis into a median eminence and a neural lobe may thus have taken place at an earlier stage in vertebrate evolution than previously assumed.

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Sensory Innervation of the Anal Canal

Duthie and Gairns in a short communication[1] directed attention to the rich sensory innervation of the mucosa of the human anal canal.

This is a preliminary report of a further investigation of the sensory innervation of the anal mucosa and of the adjacent external (voluntary) anal sphincter.

Autopsy and operative specimens of whole human anal canals, excised with the last centimetre or so of the rectum and the attached circumanal skin, were fixed in 10 per cent formal saline. Fresh specimens of cat and rat anal canals were similarly fixed. Longitudinal serial 7½-μ sections through the canals were either stained with Erhlich's hæmatoxylin and eosin, or impregnated with silver according to Bodian's silver protargol method, using silver proteinate obtained from Roque's Laboratory, Paris[2]. Other blocks of material were impregnated according to the Bielschowsky method for pieces with pyridine treatment[3], and then serially sectioned at 7½μ. Frozen 20-μ sections of the fixed rat material were impregnated by the Bielschowsky–Gros silver diamine ion technique[4].

In the human material the distribution of the encapsulated, or organized, sensory nerve endings conforms to Weddell's generalization[5] that such endings are only found in non-hairy skin.

Three kinds of encapsulated ending were found, lying either immediately beneath the stratified epithelium of the canal or deep in the connective tissue of the lamina propria.

The largest endings are approximately 900μ in size and possess an elongated lamellated capsule similar to that of Pacinian corpuscles. The nerve terminals, however, are not of the simple kind found in Pacinian corpuscles but are branched and coiled (Fig. 1). This large variety of ending is only infre-

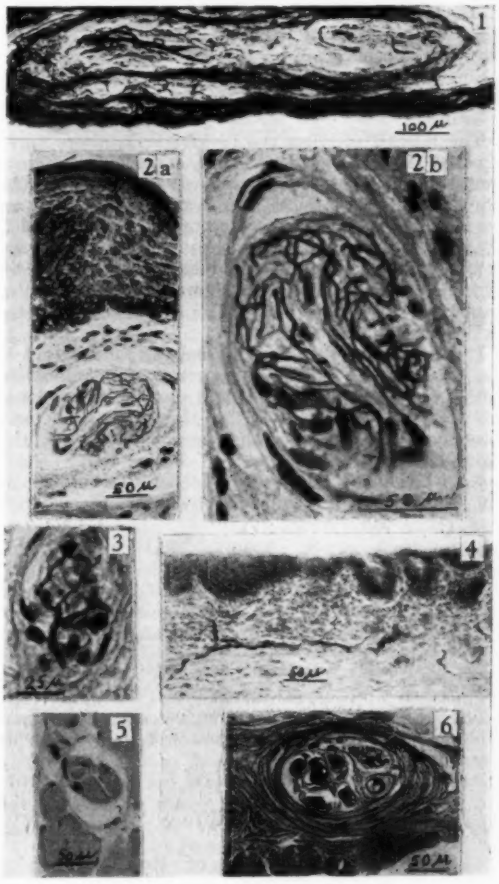

Fig. 1. Large encapsulated nerve ending. Fig. 2*a*. Low power showing medium-sized, organized ending lying under anal epithelium. Fig. 2*b*. High power of same ending showing the reticulum of sensory nerve endings. Fig. 3. Small organized ending. Fig. 4. Plexus of free nerve fibres at junction of rectal type epithelium and stratified squamous epithelium of anal canal. Fig. 5. T.S. muscle spindle from cat external sphincter. Fig. 6. T.S. muscle spindle from human external anal sphincter

quently found, usually lying close to the smooth muscle of the internal spincter.

The most prevalent ending is globular or oval in shape, some 200μ in diameter. The nerve terminals form a branched tangled reticulum surrounded by a fairly simple capsule of connective tissue fibres and cells (Figs. 2*a* and *b*).

Fig. 3 shows the smallest kind of end-bulb, 100μ in diameter. Their nerve terminals are branched but relatively uncomplicated in their ramifications.

These encapsulated endings are most numerous in the mucosa of the upper part of the canal—six or more endings may often be observed in one section—and gradually become sparser in distribution as the anal orifice is approached.

Unencapsulated naked nerve terminals form a particularly rich subepithelial and intraepithelial plexus. In the circumanal skin typical peritricheal endings and free nerve endings were observed, but no organized endings.

No encapsulated endings were found in the rat anal mucosa, only a plexus of free nerve terminals, which was particularly obvious in the first segment of the canal (Fig. 4).

Proprioceptive endings of the muscle-spindle kind were observed in both human and cat external sphincters (Figs. 5 and 6). The correlated physiological observations in the cat have been reported elsewhere[6].

The human spindles are histologically more complicated than those found in the cat. Their connective tissue capsule is thicker and usually there are more intrafusal fibres present. Often the intrafusal fibres are arranged in two separate groups, each surrounded by its own connective tissue sheath, and both groups bound together in a common capsule. In serially sectioned cat sphincters not more than six spindles have been counted. They appear to be equally sparse in human sphincters.

It is concluded that the rich sensory innervation of the anal mucosa and the proprioceptive endings in the external sphincter provide a morphological basis for the extreme sensitivity of the anal region and must be taken into consideration in explaining the physiology of defæcation.

May I thank Prof. E. W. Walls for his directing my attention to this problem and his guidance throughout the work.

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BIOLOGY

Laminated Structure of Bones from Some Marine Mammals

In recent years much attention has been paid to methods of age determination for marine mammals, and several reliable techniques are now available. Ovarian corpora albicantia counts[1,2], baleen plate ridges[3], internal growth layers in the dentine and cementum of teeth[4], and laminations in the ear plug of baleen whales[5] are in use. Certain of these techniques have been applied with success to some terrestrial mammals, notably the method based on tooth structure[6,7]. In other species, marine and terrestrial, these methods cannot be used.

Fig. 1. Photograph of polished section of left ramus of lower jaw of an adult male sperm whale

In 1953 I described and figured the layered appearance of the dense bone of the tympanic bulla of some elephant seals, *Mirounga leonina* L.[8], but was then unaware of a paper by Chapskiy[9] in which he describes and figures such layers in the mandibles of *Phoca groenlandica* and *Odobenus rosmarus*. He showed that the number of layers is correlated in a general way with estimates of age based on other characters, and suggested that the layers are annual formations. The greatest number present in his relatively small sample of harp seals was 25. He mentions that this layered structure is found in other bones and gives reasons for preferring the mandible for routine use. It is usually the most convenient bone to collect.

I recently had occasion to examine the lower jaw of a large male sperm whale, *Physeter catodon*, caught in the Antarctic. The ventro-lateral part of the mandible is composed of compact bone, some 3–4 cm. thick in places, in contrast to the remaining spongy bone. In section it shows a number of distinct layers (Fig. 1).

These layers may be of fairly general occurrence and the purpose of this communication is to direct attention to them as a possible method of age determination. Chapskiy's important paper[9] would appear not to be generally known to biologists interested in these problems. Dr. D. E. Sergeant of the Arctic Unit, Montreal, has confirmed the layering of harp seal mandibles and found clear layers in *Phoca vitulina*, *Phocaena* and *Delphinus*. These layers will probably be useful for ageing the small delphinids, with minute teeth that may cease to grow at an early age. It may also be a possible method of ageing those baleen whales (for example, *Balaenoptera acutorostrata*) in which the ear plug has proved unsatisfactory. Game

biologists may find it applicable to some terrestrial mammals in which the cementum increments are too small to use for age determination.

I am indebted to Dr. Sergeant for confirming the presence of layers in the mandibles of seal and Delphinid species. Chr. Salvesen and Co. kindly provided the sperm whale jaw and Mr. A. Madgwick took the photograph.

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Dichorial One-Egg Twins in the Mouse

In a survey of the embryological evidence of one-egg twinning in man, Corner[1] has classified one-egg twins according to their time of separation, as follows:

(1) Separation of early blastomeres inside the zona pellucida. Each then develops its own blastocyst, the two becoming completely separate on dissolution of the zona, and implanting separately in the same way as two-egg twins.

(2) Duplication of the inner cell mass in a single blastocyst. The two embryos implant together; but their amnia and placentæ are separate.

(3) A single inner cell mass differentiates two primitive streaks. The embryos will have a common amnion. Imperfect duplication of the primitive streaks will give all stages from Siamese twins to two-headed monsters.

The evidence for type 1 consists of two extreme sets of data. On one hand, it has been found in the rat[2] and rabbit[3] that after killing one blastomere at the two-cell stage, the other one is capable of developing into a normal embryo. The potentiality of a single blastomere to develop into an embryo does not, however, prove that *two* blastomeres confined within the same zona could both develop into embryos. One might expect considerable mechanical difficulties in the production of two blastocysts in the confined space. No one appears to have seen, among the thousands of mammalian ova examined (I have inspected hundreds of mouse eggs myself), any instance of two complete ova developing within one zona pellucida.

At the other extreme are the numerous examples of dichorial one-egg twins, which independent workers[4,5] have estimated to represent one-third of all one-egg twins.

The evidence for type 2 is more conclusive. At one end of the scale, isolated instances of blastocysts with two inner-cell masses have been recorded in sheep[6] and pig[7]. At the intermediate level Corner[1] gives examples of early human monochorial twin embryos with separate amnia, placentæ and yolk sacs (though sometimes one yolk sac is shared). At the other end of the scale, the majority of full-term one-egg twins are monochorial with separate amnia.

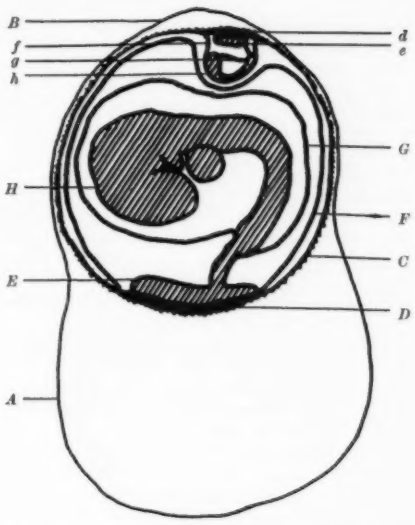

Fig. 1. Diagrammatic representation of monozygotic twin embryos in the mouse at 9½ days gestation. The uterus is not represented. *A*, Decidua basalis; *B*, decidua capsularis; *C*, trophoblast. For the other symbols, capitals stand for structures of the larger (normal) embryo and small letters for structures of the smaller (retarded) embryo. *Dd*, Ectoplacental cone; *Ee*, chorion; *Ff*, yolk sac; *Gg*, amnion; *Hh*, fœtus

Type 3, illustrated by numerous human examples of twins with a common amnion, can be readily induced in Amphibia and fish. It is also the normal reproductive method in armadilloes[8], where four or eight embryos, according to the species, develop from a single egg.

I have obtained evidence of type 2 in mice, in circumstances which explain why it has not been recorded more frequently, and throws new light on the distinction between monochorial and dichorial twins. While dissecting early mouse embryos I have twice found in females, 9½ days from insemination, among numerous normal embryos, one implantation with two separate embryos within a single trophoblast (Fig. 1). The embryos were at opposite ends of the vesicle. Judging by the sheep and pig blastocysts, this is the usual arrangement. The one at the mesometrial end, attached to the decidua basalis, was much the larger of the two. In the mouse, placentation is restricted to the mesometrial line. Only the larger twin, therefore, has any future. The placenta is beginning to develop at 9½ days. The distal embryo has probably already ceased to grow and will soon be stretched out of existence by the expansion of the distended trophoblast. This makes it unlikely that one-egg twins in mice could be recognized later than 9½ days, but one would expect to have found them at earlier stages with less discrepancy in size. That I have not yet done so may be merely a matter of chance. It is just conceivable that the smaller embryo at 9½ days is secondary, developing after the larger, from trophoblast. This would account both for its small size and its absence from earlier stages.

In man, where placentation is unrestricted, both embryos such as those found in the mouse would be free to develop their own placenta and would have equal chances of survival.

Other forms of 'twinning' in the mouse are undoubtedly two-egg. It is common for two advanced (12½ days) embryos to share a common implantation site, with separate though contiguous placentæ. In litters segregating for albino these twins will often be found to differ in eye colour. I have also found two trophoblasts, one above the other at the same site. In this case they were both greatly dwarfed, presumably because each had inhibited the other.

It will be noticed from Fig. 1 that the one-egg mouse twins with a single trophoblast are dichorial, whereas most one-egg human twins are monochorial. This is because the two animals have very different types of chorion. That of the mouse is formed of extra-embryonic mesoderm, in contact with a restricted area of trophoblast, the ectoplacental cone, from which the placenta later develops. By contrast, the human chorion envelops the embryo and yolk sac. According to Corner (personal communication) it is formed from trophoblast, though it is vascularized by mesenchyme from the allantois.

The significance of dichorial one-egg twinning will obviously depend on the origin of the chorion, and since mouse chorion and human chorion do not appear to be homologous, the significance of such twins will be different in the two species. In the mouse, as in the cases described in this communication, they will signify duplicate inner cell masses from a single blastocyst (type 2). In man they will signify duplicate trophoblasts (two blastocysts from a single egg: type 1). There remains the problem of how two viable blastocysts could develop inside the same zona pellucida.

It is a pleasure to acknowledge the generous advice of Dr. George Corner of the Rockefeller Institute, New York, and of Mr. S. Bender of Chester.

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Wound Healing in the New-Born Opossum (*Didelphis virginianam*)

While engaged in experiments on the development of feathers in chick embryos, Saunders and Weiss[1] noted that skin wounds failed to heal when the embryos were less than 3 days old. On further investigation Weiss and Matoltsy[2,3] found, for unknown reasons, that this inability to initiate wound healing persisted until the chick embryos were at least 10 days old.

Because of the absence of an accessible experimental subject, it had not been feasible to investigate wound healing in very immature mammalian embryos. However, I have found that the new-born opossum (*Didelphis virginianam*), because of its 12-day gestation period, is an exceptionally suitable subject for elucidation of this problem in mammals. At birth the opossum is physiologically and anatomically an embryo, corresponding in development to the following embryos: 10-day chick, 12-day rat and mouse, 13-day rabbit, 28-day guinea pig and 8-week human.

Two types of skin wounds were made in opossums 1–40 days old. The first series consisted of a non-sterile incision 2–4 mm. in length and extending into the muscle. The second series were burns of the same size made by application to the skin of needles heated at 200° to 210° F. The incised wounds became grossly infected; the burns did not.

There was a 90 per cent mortality within 2 or 3 days of injury in animals less than 6 days of age with wounds induced by incision. This mortality decreased with advancing age so that the mortality was less than 2 per cent in animals of 10 days of age and older. In contrast, the mortality following a burn was less than 10 per cent in animals less than 6 days of age, and had decreased to zero in animals at least 10 days of age.

In all animals less than 6 days of age there was an almost complete lack of inflammatory reaction at the site of injury. The slight increase in cells was due to a few mitoses in local mesenchymal cells. This lack of reaction was unimportant when the wound was essentially sterile, and when there was little tissue necrosis, as occurred following the burn. In these circumstances the local mesenchymal cells were able to remove the debris and form a suitable base for spread of the epidermis over the ulcer. In contrast, when the wound became infected, as occurred after the non-sterile incisions, or if the burn was unusually deep, causing marked tissue necrosis, the injury became the site of a massive gangrenous infection resulting in death of the fœtus.

However, in all animals beginning 6 days of age the local injury elicited an intense mononuclear inflammatory response. The inflammatory cells successfully combated the local infection and within 48 hr. removed all necrotic tissue, leaving a clean base across which the epidermis bridged the defect.

The difference in reaction prior to, and subsequent to, 6 days of age was explicable by examination of the blood and hæmatopoietic tissues. Before 6 days of age there was not sufficient development of the hæmatopoietic tissues to produce significant numbers of white blood cells for the circulating blood. As a result the local mesenchyme was the only source of inflammatory cells to clear necrotic tissue and control infection. Thereafter, with progressive development of the hæmatopoietic tissues a large number of white blood cells entered the circulating blood and were able to supplement the mesenchymal cells at the site of injury as a source of inflammatory cells. The inflammatory reaction was almost as effective between 6 and 10 days of age, when the only apparent source of lymphocytes was the thymus, as after 10 days of age when lymphocytes were derived from the spleen and nodes as well as from the thymus.

These results suggest that in the opossum of less than 6 days of age wound healing ensues even in the absence of an intense inflammatory reaction provided the injured area is small and the lesion remains sterile. When the area is infected or when there is extensive local injury in animals less than 6 days of age, wound healing does not occur because the local mesenchymal cells alone are unable to control injection and clear debris. Only after 6 days of age have the hæmatopoietic tissues of the opossum developed sufficiently to provide an adequate number of circulat-

ing leucocytes to serve as a source of inflammatory cells. It thus seems probable that the leucocytes of the circulating blood and not the local mesenchymal cells are the major source of the inflammatory cells needed for wound healing in the embryo-like new-born opossum.

I thank the Texas Game and Fish Commission for obtaining the animals and Braniff Air Lines for flying the animals from Waco, Texas, to Denver, Colorado.

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Development of the Gonads in Parasitic and Non-Parasitic Lampreys

In relation to the origin of the non-parasitic brook lampreys the view now generally accepted is that these forms have arisen from closely related parasitic species by virtue of a precocious development of the gonads[1–3]. As a result, sexual maturity is attained so soon after metamorphosis that the migratory, parasitic phase has been eliminated from the life-cycle. The recent discovery of neotenous female ammocœtes of the Italian brook lamprey, *L. zanandreai* Vladykov[4], tends to support the view that brook lampreys show an inherent tendency towards pædomorphosis.

Through the co-operation of Dr. V. C. Applegate, of the U.S. Department of the Interior, Fish and Wildlife Service, it has been possible to examine the condition of the gonads in ammocœtes of the parasitic sea lamprey of the Great Lakes Basin, *P. marinus*, and to compare the pattern of gonad development in this species with that of the brook lamprey, *L. planeri*.

Length-frequency curves for 847 ammocœtes of *P. marinus* collected in the Oqueoc River, Michigan, in September 1957, suggest the presence of six age classes with frequency maxima at about 25, 55, 80, 105, 124 and 140 mm. Metamorphosing specimens were found in the size-range 123–170 mm. with a frequency peak at about 145 mm. Since the 25-mm. group represents the young of the year, it is thought that the duration of the larval period is similar to that of the brook lamprey[5], that is, about five years.

To compare the size of the gonad in the two species transverse sections were cut through the mesonephric region and either photographed or traced with the camera lucida. The area of the gonad was then measured planimetrically and expressed as

$$\frac{\sqrt{\text{gonad area in mm.}^2}}{\text{total length mm.}} \times 100$$

For the first year of larval life (up to about 30 mm.), the gonad of *L. planeri* is in the proliferative phase during which the small number of germ cells present at hatching undergo successive divisions to produce follicles of undifferentiated gonia. By the early spring of the second year (35–40 mm.) some gonads already contain oocytes in the earlier stages of cytoplasmic growth. In the definitive ovary, growth is now rapid,

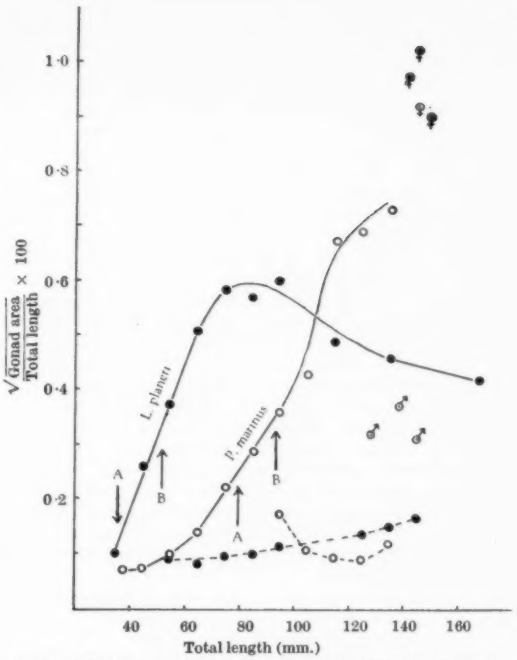

Fig. 1. Relative growth of gonads in ammocœtes of *P. marinus* and *L. planeri*. Continuous lines, ovaries and indeterminate gonads; broken lines, testes; ♀, metamorphosing females; ♂, metamorphosing males of *P. marinus*. The arrows at *A* and *B* indicate respectively the appearance of auxoytes and the onset of sex differentiation

and the gonad soon consists almost entirely of auxocytes. However, in a small proportion of ammocœtes, the gonad remains small with follicles of gonia only, while others contain, in addition to such follicles, a smaller number of oocytes. Future testes are recognizable at this stage only by their small size, relatively fewer auxocytes, and the presence of undifferentiated gonial follicles. By the summer or autumn of the second year, at lengths of about 50–60 mm., differentiation of the gonads is almost completed but the testes show little further growth between this period and metamorphosis.

The rapid initial growth of the oocytes is reflected in the increase in size of the gonad between 35 and 75 mm. total length (Fig. 1), beyond which the relative size of the ovary actually diminishes. There is, however, a final phase of growth, not represented in the graph, between metamorphosis and full sexual maturity, during which the diameter of the oocyte is increased from about 0·12 mm. in the largest ammocœtes to 1·0 mm. at the time of spawning.

Initially the gonads of *marinus* ammocœtes are smaller than those of *planeri* and grow more slowly up to a length of about 100 mm. Thus, in a 100-mm. sea lamprey ammocœte the gonad is no larger than that of a brook lamprey at 55 mm. and, up to lengths of 70–80 mm., it still consists of undifferentiated germ cell follicles. This extension of the period of proliferation must, of course, be associated with the vastly greater number of oocytes (or spermatocytes) produced by the sea lamprey. Oocytes in the first growth-phase occurred in the majority of animals at 80–90 mm.; but it was not possible in all cases to distinguish the definitive ovary and testis at lengths below 90–100 mm. Growth of the ovary appears to be

most marked between 105 and 115 mm., and in animals above this length the gonad is relatively larger than in the corresponding brook lamprey ammocœtes. This increased size is due to the larger number of oocytes; a single transverse section often containing as many as 200 oocytes compared with an average of about 30 in the brook lamprey, while the oocytes themselves are smaller than those of *planeri* (mean diameter in the largest ammocœtes 0·3–0·4 mm. compared with 0·12 mm.). Judging from the size of the gonad in metamorphosing animals, a marked acceleration of growth must occur in both ovary and testis at this time.

Although the duration of the larval period and the linear growth-rate appear to be similar in the two species there are thus very marked differences in gonad development, both sex differentiation and oocyte growth occurring at a much earlier stage in *planeri* ammocœtes. In considering the relevance of these findings to the question of speciation in lampreys it must, however, be recognized that, except for its earlier differentiation in the brook lamprey, there are no obvious indications that the testes of these animals are in a more advanced state of development and it may perhaps be significant that all the cases of neoteny reported by Zanandrea[4] occurred in female ammocœtes.

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An Acid-tolerant and Non-sporulating Yeast from Passion Fruit Juice

During the course of studies in the preservation of passion fruit juice (*Passiflora edulis*, Sims.)[1,2], a survey of literature revealed little published information on the nature of spoilage organisms present in the juice.

Passion fruit juice normally has 14·4–21·9 °Brix, 2·4–4·8 per cent acidity (as anhydrous citric acid), 2·60–3·22 *p*H, 3·6–8·3 per cent reducing sugars and 7·4–13·3 per cent total sugars (as invert)[3]. The juice, though acidic, is fairly rich in sugars and is easily fermentable[1]. A fermenting sample of the juice, when examined microscopically, revealed the presence of yeast cells only. No bacteria were noted.

The spoilage organisms were isolated by plating them out on potato–dextrose–agar[4] and transferring the well-defined colonies to slants of the same medium. Taxonomic studies[4,5] revealed the presence of two strains of yeast, one of which was identified as *Candida krusei*[6]. The summary of morphological and physiological studies on the other organism (*Passiflora* strain) is given below.

Cells small, oval (1·8–4·5) × (1·8–8·8) μ; no formation of pseudomycelium; a sediment after a week and a ring after a month in liquid media; no sporulation on carrot, Gorodkowa agar, potato malt-extract agar, etc.

Only glucose is fermented and assimilated. The following compounds are not assimilated by this *Passiflora* strain: galactose, sucrose, maltose, lactose, L-sorbose, cellobiose, trehalose, melibiose, raffinose, melezitose, D-xylose, L-arabinose, D-arabinose, D-ribose, rhamnose, erythritol, adonitol, dulcitol, mannitol, sorbitol and methyl glycoside, salicin, lactic acid, succinic acid and citric acid. Ethanol may be weakly assimilated. Nitrate is not used, and arbutin is not split.

The *Passiflora* strain resembles *Torulopsis glabrata* (Anderson) Lodder and de Vries, but differs from this species in that the latter ferments trehalose.

Comparing the strain to sporogenous species, it bears resemblance, in fermenting dextrose only, to: *Sacch. bisporus* (Naganishi) Lodder and van Rij, *Sacch. mellis* (Fabian and Quinet) Lodder and van Rij, *Pichia pastori* (Guilliermond) Phaff and *Sacch. delphensis* van der Walt and Tscheuschner[7].

The cells of *Sacch. mellis* and *Sacch. bisporus* are somewhat bigger than those of the *Passiflora* strain, though the difference with *Sacch. bisporus* is not great. However, *Sacch. bisporus*, *Sacch. mellis* and also *Pichia pastori* can assimilate mannitol and sorbitol, which compounds are not used by the *Passiflora* strain.

On the other hand, the assimilation tests of the *Passiflora* strain and *Sacch. delphensis* show much correspondence, differing only by a weak assimilation of succinic acid found in the latter. For growth, both strains need the addition of vitamins to the medium. They grow at 37° C. Also in the morphological properties, there is similarity, apart from the formation of kidney-shaped spores after isogamous conjugation in *Sacch. delphensis*. This species has been isolated from the sugary efflorescense on dried figs (Kregar-van Rij, N. J. W., private communication).

Based on the above observations, we are inclined to consider the *Passiflora* strain provisionally as a non-sporulating strain of *Sacch. delphensis*.

We are indebted to Mrs. N. J. W. Kregar-van Rij, Centraalbureau voor Schimmelcultures, Yeast Division, Julianalaan 67*A*, Delft, Holland, for help rendered in the identification of the yeast, to Dr. Girdhari Lal, assistant director, and Dr. V. Subrahmanyan, director of this Institute, for their keen interest in this investigation, and to Shree S. A. Jaleel, for assistance in the work.

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Ensete berryi: Revised Name for *Musa ensetefor mis* Berry

Working on some petrified plants from the Deccan Intertrappean Series of India, I have found certain well-preserved specimens of fossil bananas to be described in detail elsewhere. Looking into the geological history of the genus *Musa*, I find that *Musa enseteformis* Berry[1] is the only definite palæobotanical record of the old genus *Musa* L. This species was based on some carbonized seeds recovered

from the coal beds of Cerros de Guadalupe and Montserrate in the eastern border of the Sabana of Bogota, Colombia. The exact horizon from which these seeds were obtained was not known; but Berry considered them to be of Oligocene age.

Recently, Cheesman[2] has split the old genus *Musa* into *Ensete* Horan. and *Musa* L. As evident from their structure and as suggested by the specific name *enseteformis*, the seeds described by Berry[1] are clearly referable to the newly revived genus *Ensete*. In the light of these facts, the name of *Musa enseteformis* should be revised. Usually in such cases the generic name is changed and the specific name is combined with it. But to avoid the repetition of the generic name in the specific epithet, I propose a new combination *Ensete berryi*, with the specific name in honour of the original author.

My sincere thanks are due to Dr. R. N. Lakhandal for going through this communication critically.

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Unproductivity in the Colchicine-induced Tetraploids of *Annona squamosa* L.

Only two out of a large number of colchicine-treated *Annona squamosa* plants reported earlier[1] proved pure tetraploid on chromosome examination. The one suspected to be tetraploid on morphological grounds and reported in that paper to have borne fruits earlier than the control was found to be diploid. The two pure tetraploids have been under observation since 1951 but until now neither of them has borne any fruit although they come to blossom every year. The flowers on both these plants wither away on the day following their opening.

Selfing did not help in the fruit formation nor pollination by the pollen from the diploid parent. Application of hormone on the flower stalk did not also prevent the shedding of flowers. The addition of nitrogen, phosphorus and potassium in various combinations, and the root exposure did not improve the situation.

Fig. 1. (*a*) and (*b*), Side view of metaphase I showing 1_{III}, 10_{II} and 5_{I} and 1_{III}, 7_{II} and 11_{I} respectively. × 1,200

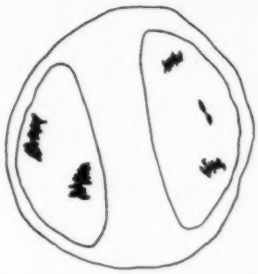

Fig. 2. Side view of anaphase II. Note the lagging chromosome in the right-hand cell. ×600

In order to understand the causes of unproductivity meiotic studies were made from pollen mother-cells in aceto-carmine. Early stages of prophase could not be studied as the chromosomes took feeble stain. None of the diakinetic nuclei studied showed any quadrivalents. Trivalents, bivalents and univalents were only found, the maximum number of trivalents and univalents observed in any pollen mother-cell being 3 and 7 respectively. The side view of metaphase I was studied from 30 pollen mother-cells. Various associations of trivalents, bivalents and univalents were seen, the number of trivalents ranging mostly from one to two and that of univalents from three to as many as eleven. Figs. 1*a* and *b* show one trivalent and five and eleven univalents respectively. The presence of trivalents and a large number of univalents led to a more unequal segregation of the chromosomes at anaphase I than what would have been expected if the quadrivalents were present in place of trivalents and univalents. Lagging chromosomes were also seen in anaphase I as well as in anaphase II (Fig. 2).

These meiotic irregularities resulted in the formation of sporads containing from 1–5 cells (Fig. 3). Some of the sporads formed a linear tetrad instead of the usual isobilateral type. A count of the unstainable pollen grains showed that these were present to the extent of about 80 per cent. Megasporogenesis has not been studied, but it may be presumed that this

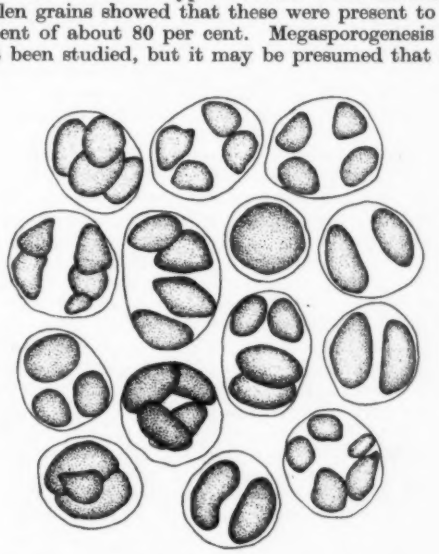

Fig. 3. One- to five-cell sporads in the *c*-tetraploid *Annona squamosa* L. × 275

kind of irregularity in meiosis may lead to a high percentage of aborted megaspores. Chances are therefore very remote for a normally developed megaspore to be fertilized by a balanced male gamete. Thus the failure of fruit formation may be primarily due to irregular meiosis which results in the abortion of as much as 80 per cent pollen grains and possibly the same percentage of megaspores.

The artificial induction of polyploidy always brings about sterility in the induced plants but the report of complete sterility in the colchicine-induced tetraploids is rare. The complete unproductivity of the *c*-tetraploid *A. squamosa* is quite contrary to the expectation as the experiments on induced polyploids in the past have shown that cross-pollinated diploid plants with a low number of small sized chromosomes (to which class *A. squamosa* belongs) respond favourably to the action of chromosome doubling[2].

I gratefully acknowledge the financial assistance received from the Food and Agriculture Council of Pakistan in carrying out this piece of research work. My thanks are also due to Dr. Majeed Ahmad, University of Dacca, for giving me facilities to work in the laboratory and the botanic garden where the two tetraploid plants are growing.

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Intracellular Configuration and Dedifferentiation in *Splachnum ampullaceum* (L.) Hedw.

In studies on protonematal regeneration from gametophore leaves of *Splachnum ampullaceum* (L.) Hedw., it was found that isolation and not wounding is the most important factor in the realization of regenerative potentialities[1]. The removal of correlative inhibition by means of isolation initiates cellular dedifferentiation, followed generally by cellular redifferentiation. The present work was undertaken in order to investigate certain aspects of cellular dedifferentiation.

The plant material was grown under sterile conditions on Beijerinck's inorganic medium solidified with 1 per cent agar and was kept under continuous white light provided by fluorescent lamps. Cells of detached half-leaves were compared with those of half-leaves attached to a stem segment. Protonematal regeneration occurs readily from cells of the former while it does not occur from those of the latter[1].

Table 1 shows a comparison of nuclear size and chloroplast size and number between cells of attached and detached half-leaves. Measurements were made at selected time-intervals following the surgical treatment. Cells in the immediate neighbourhood of the wound surface are not included. These results show that nuclear size increases considerably in cells of the detached half-leaves during the first 24 hr. after isolation while remaining approximately constant in cells of the attached half-leaves. Similarly, chloroplast size decreases slightly and chloroplast number increases greatly in cells of detached half-leaves while remaining approximately unchanged in attached half-leaves. Since attached and detached half-leaves have about the same wound surface present, the recorded changes in the nuclei and chloroplasts are due not to wounding but to leaf isolation. Isolation, therefore, results apparently in greatly increased synthetic activity of the cells. Preliminary comparisons between cells of older detached half-leaves and those of younger ones indicate that these changes occur at considerably slower rates in the cells of the older leaf.

Table 1. Nuclear Size, Chloroplast Size and Number in Cells of Attached and Detached Half-Leaves

Hr. after treatment	Diameter of nucleus (mm. × 10^{-2})		Diameter of chloroplast (mm. × 10^{-3})		No. of chloroplasts	
	Attached	Detached	Attached	Detached	Attached	Detached
0	6·39	6·14	6·03	6·20	73	65
10	6·14	6·52	6·08	6·05	69	66
24	6·68	7·50	6·13	5·49	75	99
48	6·29	—	6·06	—	75	—
72	6·74	—	6·11	—	79	—

Fundamental changes in the relative position of the various cellular components in cells of detached half-leaves precluded observations on nuclear size and chloroplast size and number beyond 24 hr. after isolation. In a mature leaf cell the cytoplasm is limited to a thin layer along the cell wall surrounding a large vacuole. Under the present light conditions the chloroplasts are in peristrophe. The nucleus is in a peripheral position. While this pattern is maintained in cells of the attached half-leaf, there is a pronounced change in cells of the detached leaf. Within a few hours after isolation intravacuolar strand formation is observed, a primary cytoplasmic strand being formed first connecting the cytoplasm around the nucleus with the cytoplasm at the side opposite the nucleus across the vacuole (Fig. 1). Primary cytoplasmic strand formation is followed by the formation of other strands reaching a maximum

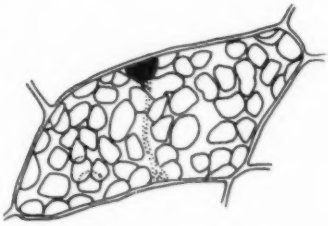

Fig. 1. Surface view of leaf cell 6 hr. after leaf isolation

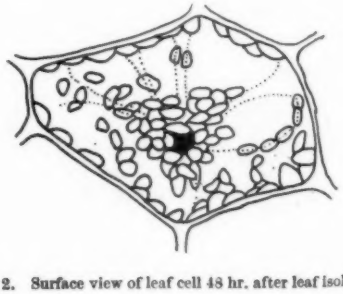

Fig. 2. Surface view of leaf cell 48 hr. after leaf isolation

between 24 and 48 hr. after isolation of the leaf. Intravacuolar strand formation is followed by the movement of the nucleus and the chloroplasts from a peripheral to a more central position in the cell. Hence the cytoplasmic strands facilitate a clustering of cytoplasm and chloroplasts around the nucleus, resulting in a typical systrophe or cluster formation (Fig. 2). Ultimately one cytoplasmic strand becomes the most prominent one, and cell wall formation is initiated along this strand. This strand represents, therefore, the phragmosome[2]. The remaining strands disappear gradually.

Strand formation leading to systrophe is, therefore, an important event in cellular dedifferentiation and results here simply from isolation. These results are in agreement with Heitz's[3] important observations on regeneration and his suggestion that wounding cannot be the important factor in the initiation of events leading to cellular regeneration. Sinnott and Bloch[2] have described cell division in vacuolate plant cells in normal plant development. Their illustrations show strand formation resulting in a more central position of the nucleus and cytoplasmic cluster formation around the nucleus. Thus in normal plant development enlarging yet still actively dividing cells undergo dedifferentiation accompanied by cytoplasmic cluster formation before each division. Hence changes in intracellular configuration which occur during dedifferentiation and which in the present instance are the result of isolation appear also to be a characteristic of normal plant development.

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ENTOMOLOGY

Prevention and Artificial Induction of the Imaginal Diapause in *Coccinella 7-punctata* L.

By field observations, dissections and analyses of field samples it was discovered that the female diapause in *Coccinella 7-punctata* L. (Col. : Coccinellidae) is connected with a gonotrophic dissociation, which is not the case in male individuals. After the induction of diapause the adults of both sexes accumulate reserves (fats and glycogen) ; afterwards they stop feeding and migrate towards the winter quarters. During this prehibernation accumulative feeding-period, the females remain sexually immature. On the other hand, for males the maturation of gonads is not such a strain on energy reserves ; both diapausing and active males rapidly reach maturity and only stop tissue activity in testicular follicles immediately before hibernation. At this period they have already accumulated sperm reserves in the seminal vesicles and encysted sperms in the testicular follicles. Already before hibernation they fertilize a part of the females, hibernating afterwards with sperm reserves in the spermatheca. In the spring the males renew their sexual activity long before the females. They fertilize females in the hibernating quarters. The ovaria mature later—only after feeding on the essential aphid food. During hibernation the fat reserves in both sexes are reduced to a half ; the glycogen in males to one-fifth, in females to one-third.

A mixed population, consisting of monovoltine insects with the obligate diapause and of polyvoltine insects with the facultative diapause, obviously lives in Central Europe.

In order to reveal the mode of action of factors inducing the diapause we tried to prevent this phenomenon experimentally and, on the other hand, to induce it artificially.

By breeding the Coccinellidae under optimal conditions of a continual excess of food (aphid *Pergandeida medicaginis* Koch), long photoperiod (16–18 hr.) and a higher slightly alternating temperature (mean 25° C. ; 22–28° C.) we succeeded in gradually preventing the diapause[1]. It is obvious that a gradual selective elimination of the monovoltine insects resulted. It is then possible to breed the ladybirds continuously. When any departure from the optimal culture conditions has arisen (especially from excess of food in cages with many individuals) a certain amount of diapausing ladybirds also developed in the next generations. This situation is very similar to that in *Leptinotarsa* 10-*lineata* Say. The possibility of interpreting this feature in the same way in both these insects arises from the results by De Wilde and Stegwee[2] : they found a marked decrease of the number of diapausing females in the cultures of single pairs of *L.* 10-*lineata*.

Experiments with polyvoltine Coccinellidae from artificial cultures showed that there is a correlation between the photoperiod and temperature in the induction of imaginal diapause, the photoperiod being the more significant factor[3]. The long photoperiod (16 or 19 hr.) appears to prevent the diapause even at a relatively low temperature (18° C.). The short photoperiod (8 or 12 hr.) induces the diapause. In a short photoperiod the induction of diapause is stimulated in addition by a low temperature ; but inhibited by a high one.

The character of the artificially induced diapause was studied by comparative dissection and analysis. Dissection did not reveal any differences in the fat body and ovaria. Analysis showed that females with artificially induced diapause had the same glycogen reserve, and that the fat reserve was only one-fifth lower than in the naturally diapausing females. On the other hand, in experimental active females the fats were less than a half and glycogen just half the amount in the experimental diapausing females. On the basis of these results, the artificially induced diapause can be considered equivalent to the natural diapause.

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Immunity of Aphids to Insect Parasites

A study has been made of the susceptibility to, or immunity from, parasitism which certain aphis exhibit towards the insect *Monoctonus paludum* Marshall (Hymenoptera, Braconidae). Starý[1], in a recent revision of the European species of *Monoctonus*, identifies *M. paludum* with *M. crepidis* Haliday, which has been recorded from various aphid hosts on plants related to lettuce. The present account is concerned only with the association between the parasite and aphids which occur on lettuce, and it has been found that although the parasite will readily oviposit into the five species of lettuce aphids which have been studied, successful development of the parasite can only occur in one of these species.

During oviposition the female parasite lays a single egg, with precision, into the fused thoracic ganglia of each aphid, and it has been shown[2] that the parasite will readily attack the following species of aphids occurring on lettuce: *Nasonovia ribis-nigri* (Mosley), *Macrosiphum euphorbiae* (Thos.), *Myzus persicae* (Sulz.), *Aulacorthum solani* (Kalt.), *Aulacorthum circumflexum* (Buckton).

However, of these five species of aphids only *N. ribis-nigri* supports successful development of the parasite's eggs and, in order to determine the reasons for failure of parasite development in the other species, sections and dissections of these aphids have been carried out at various time-intervals after attack.

A full report of this work will be given in a subsequent paper. The interesting facts which emerge at the present time are that segmentation of the parasite egg begins normally in all the aphids studied but that, in the species *Macrosiphum euphorbiae*, *Myzus persicae* and *Aulacorthum solani*, degenerative changes then occur which result in the shrinkage of the parasite tissues and their subsequent disappearance at a later stage.

In the species *Aulacorthum circumflexum*, however, a different form of immunity reaction occurs. This reaction is contrary to the contention of Flanders[3], who stated that cellular or phagocytic immunity does not occur in aphids because the number of blood cells is relatively few, for, in this species of aphid, the development of the parasite is arrested by the secretion, around it, of a capsule formed by certain of the host's blood cells. This capsule differs from the relatively thick capsules described by Salt[4–6] in a variety of different insect species as a result of artificial injection of eggs and larvæ of the parasite *Nemeritis* (Hym. Ichneumonidae) but resembles more the thin, brown capsules described by Schneider[7] in the syrphid *Epistrophe balteata* as a defence against the ichneumon *Diplazon*. The appearance of the capsule in *A. circumflexum* during its process of formation is shown in Fig. 1.

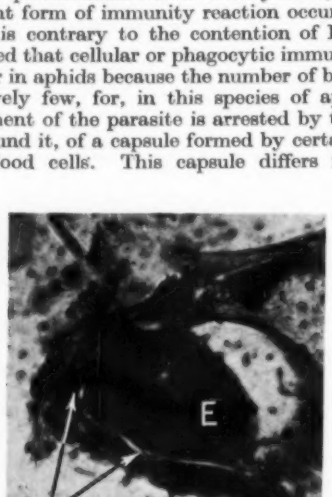

Fig. 1. Section through part of the thoracic nerve ganglia of *Aulacorthum circumflexum*, 24 hr. after attack by *Monoctonus paludum*. The capsule (*C*) is beginning to form around the parasite embryo (*E*), which lies in a space in the nervous tissue of the host

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Function of the Corpus Allatum in 'Dauer-pupa' of the Silkworm, *Bombyx mori*

Recently it was reported[1] than when the corpora allata in the Eri silkworm pupæ were transplanted into artificially diapausing pupæ which were obtained by removing their brains at early pupal time, the diapausing pupæ were induced to emerge in 25 days after the implantation. On the contrary, when the corpora allata derived from the fourth, the fifth instar larvæ or moths of the same insect were transplanted into the artificially diapausing pupæ of the Eri silkworm, most operated animals entered the second pupal instar several weeks after transplantation. The same results were obtained in an experiment on the Cecropia silkworm[2]. When the corpora allata from the Cecropia moths were transplanted into the diapausing pupæ of *Hyalophora cecropia*, the operated insects became the second pupæ.

My co-worker and I have shown[3] that in *Bombyx mori* each corpus allatum removed from the fourth, the fifth instar larvæ, pupæ and moths respectively had a function which brought about imaginal development probably through the prothoracic gland in 'Dauer-pupæ'.

It is not known, however, whether the corpus allatum in 'Dauer-pupa' of the silkworm, *Bombyx mori*, has the same function in relation to imaginal differentiation as corpus allatum in normal larva, pupa and moth.

In this communication a function of the corpus allatum in the 'Dauer-pupa' of the silkworm, *Bombyx mori*, is revealed.

So-called 'Dauer-pupæ' of an F_1 hybrid between two varieties, *J*.122 and *C*.115, which had been obtained by extirpating the brain immediately after pupation and did not show any sign of imaginal differentiation for 45 days at 25° C. after pupation, were used as recipients of the corpora allata which were removed from 'Dauer-pupæ' of 45 days old as grafts.

As shown in Table 1, of 20 'Dauer-pupæ' grafted with 3 pairs of corpora allata derived from the 'Dauer-pupæ', 11 recipients became moths 17–24 days after operation, but the other 4 animals survived

Table 1. EFFECT OF IMPLANTATION OF CORPORA ALLATA* OF 'DAUER-PUPÆ' ON THE INDUCTION OF IMAGINAL DEVELOPMENT IN 'DAUER-PUPA'

No. of 'Dauer-pupæ'† used as recipient	No. of individuals died	No. of moths emerged (days from implantation to emergence)	No. of undeveloped individuals‡
20	5	3 (17), 3 (18), 4 (19), 1 (24)	4

* Three pairs of corpora allata were implanted into each recipient pupa.
† So-called 'Dauer-pupæ' which were obtained by depriving the pupæ of their brains immediately after pupation, and kept at 25° C.
‡ The result obtained in 30 days at 25° C. after implantation of corpora allata.

having sustained the pupal form until 30 days after implantation.

Twenty control animals not implanted did not show any sign of imaginal differentiation under the same condition as the experimental animals for 100 days after pupation.

Accordingly, from this experiment, it is concluded that the corpus allatum in 'Dauer-pupa' has the same function as silkworm larva, pupa and moth.

In spite of the fact that each 'Dauer-pupa' had a pair of native corpora allata, they did not show any sign of imaginal differentiation for a comparatively long time. The reason why this phenomenon occurred is to be clarified.

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BACTERIOLOGY

Recovery in the Presence of Chloramphenicol of *Escherichia coli* B(H) irradiated with Ultra-violet Light

IT has been observed in several instances that protein synthesis is involved in the effects produced in micro-organisms by irradiation with ultra-violet light, as has been shown by changes during post-irradiation incubation. Witkin[1] and Doudney and Haas[2] obtained results which suggested the importance of protein synthesis in the induction of mutation by *Salmonella typhimurium* and *Escherichia coli* respectively, Gillies and Alper[3] in the recovery of *Escherichia coli* B and Harold and Ziporin[4] in the synthesis of deoxyribonucleic acid in *Escherichia coli* B. We have found that the synthesis of ribonucleic acid in *Escherichia coli* B(H)—a strain obtained from Prof. Itaru Watanabe, Virus Laboratory, University of Kyoto, which has a specific property in bacteriophage infection[5]—is completely dependent on the protein synthesis which occurs during the first 30 min. of post-irradiation incubation[6]. We have therefore investigated the biological and chemical nature of protein produced in this way, and some of the results are described here.

When cells of *Escherichia coli* B(H) irradiated with ultra-violet light (surviving fraction 0·1 per cent) were incubated in *tris*-glucose medium[7] at 37° C., the number of colony-forming cells increased about tenfold after 1 hr. Chloramphenicol (40 μgm. per ml.), which was added to the culture at the beginning of incubation, suppressed this increase considerably for at least 2 hr. When, however, the drug was added after incubation for 30 min., recovery was not suppressed but rather stimulated as compared to the control culture which contained no chloramphenicol (Fig. 1).

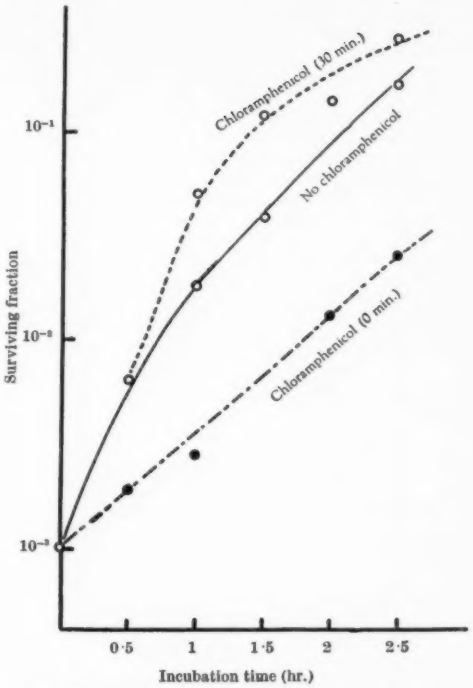

Fig. 1. Effects of chloramphenicol on the recovery of *Escherichia coli* B(H) irradiated with ultra-violet light. The numbers in parentheses show the time of addition of the drug

If protein synthesis during the first 30 min. of incubation is essential for the recovery of the irradiated cells, as suggested by the above experiment, the protein which has already been synthesized as a result of the first irradiation and the following incubation might also be useful during recovery after a second irradiation.

Cells of *Escherichia coli* B(H) in logarithmic growth phase were harvested and irradiated with ultra-violet light; this resulted in a decrease in the number of survivors to 0·2 per cent. These cells were incubated in *tris*-glucose medium for 60 min. at 37° C. in a reciprocal shaker. During incubation the number of survivors increased about tenfold. These cells were subjected to a second irradiation with the same dose as the first one. The decrease in the number of survivors was a little more than in the first irradiation. After this, the cells were incubated in *tris*-glucose medium with and without the addition of chloramphenicol (40 μgm. per ml.). At time intervals colony counts were made by plating on to nutrient agar plates. The results are shown in Fig. 2.

In contrast to the results shown in Fig. 1, when chloramphenicol is added at time zero, it does not suppress recovery but rather stimulates it. The effect is nearly the same as when the drug is added at 30 min. after the first irradiation (Fig. 1). These

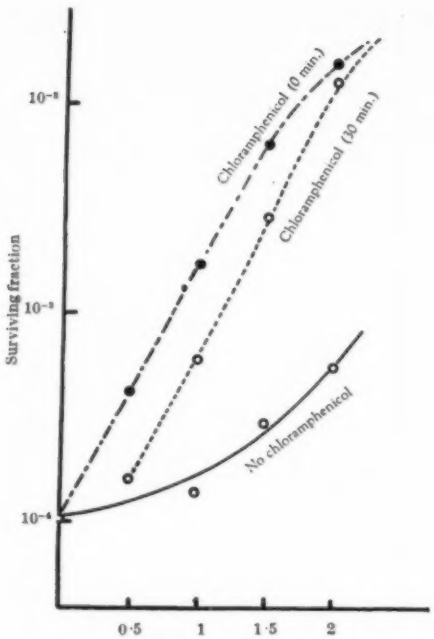

Fig. 2. Effects of chloramphenicol on the recovery of *Escherichia coli* B(H) after second irradiation with ultra-violet light. The numbers in parentheses show the time of addition of the drug

results can be explained if it is supposed that protein synthesis is not necessary for the recovery phenomenon after the second irradiation, because the essential protein has already been synthesized in the cells as a result of the first irradiation and the following incubation. That the observed increase in survival during the post-irradiation incubation is not due to cell division but to 'recovery' is indicated by the fact that it occurs even under severe conditions such as nitrogen or phosphorus starvation, addition of antibiotics, etc. Further, the rate and extent of recovery are usually very high; for example, about one hundredfold recovery is observed during incubation for 2 hr. The one-generation time for non-irradiated *E. coli* B(H) in *tris*-glucose medium is about 60 min.

Further work on the nature of this protein is now in progress in our laboratory.

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Host-Range of *Lactobacillus* Bacteriophages

In 1955, Kiuru and Tybeck[1] isolated a phage specific for 1 strain of *Lactobacillus lactis* and a phage working on 2 strains of *L. helveticus*. These phages were isolated from cultures used in the manufacture of Swiss cheese. In 1958, Meyers *et al.*[2] reported the isolation from saliva of phages active on 7 *Lactobacillus* species. The host-range of these phages was not indicated.

Using the enrichment technique of Adams[3], we have isolated 14 *Lactobacillus* phages. Media employed have been described by Briggs[4]; cultures were incubated at 37° C. in an atmosphere of carbon dioxide. Mixtures of sewage and groups of 12 *Lactobacilli* were used in different experiments. Aliquots were centrifuged daily for 10 days and the supernatant spotted on cultures of the 12 organisms. Lytic activity was never demonstrated before the second and usually only after the sixth day of incubation. The possibility that the phages originated from lysogenic members of the bacilli used for enrichment and not from sewage is being investigated. Phage was purified by picking off a single plaque into a young broth culture of the host organism. After overnight incubation, the culture was centrifuged to clarity and the supernatant titrated by the agar layer method[5] using 1 per cent tomato dextrose agar for the top layer. Repeated single-plaque isolations ensured the purity of the phage suspensions.

Lysates are identified by a number corresponding to that of the *Lactobacillus* host. Phages 300 and 316

Table 1. Host-Range of *Lactobacillus* Phages

Phages	*Lactobacillus* species						
	acidophilus (10)*	*salivarius* (7)	*casei* (11)	*casei* var. *rhamnosus* (11)	*plantarum* (10)	*fermenti* (21)	*brevis* (10)
41	0 2	0 0	0 1	0 0	0 0	7 9	1 3
69	0 0	0 0	0 1	0 0	0 0	5 11	1 3
206	0 0	0 0	0 1	0 0	0 0	9 6	1 1
222	0 1	0 0	0 2	0 0	0 0	12 5	1 2
222*a*	0 0	0 0	0 1	0 0	0 0	12 6	3 1
276	0 1	0 0	0 1	0 0	0 0	6 10	1 1
300	0 0	0 0	2 4	1 4	1 0	1 0	0 0
315	0 0	0 0	2 0	0 0	0 0	10 0	1 1
316	0 0	0 0	4 3	0 8	0 3	0 1	0 0
356	0 0	0 0	1 2	1 0	1 1	0 0	0 0
514	0 0	0 0	0 0	0 0	0 0	3 7	0 2
517	0 0	0 0	0 1	0 0	0 0	7 10	1 1
535	0 0	0 0	0 0	0 0	0 0	11 8	1 3
547	0 0	0 0	0 1	0 0	0 0	4 11	1 3

* Figures in brackets indicate number of strains tested.
Upper figure, number of strains with phage efficiency of plating equal to host strain.
Lower figure, number of strains on which only a lytic drop area was demonstrated.

are active on corresponding *L. casei* hosts; phage 356 is active on a strain of *L. casei* var. *rhamnosus*, and the remaining 11 phages were isolated on different *L. fermenti* strains.

Strains of *Lactobacilli* used were type specimens kindly supplied by Dr. M. E. Sharpe, of the National Institute for Research in Dairying, Reading, England, as well as strains isolated here from human saliva and identified by the methods of Rogosa *et al.*[5].

The host-range of the phages was determined by: (*a*) titration of 0·1 ml. of undiluted, and 10^{-3} and 10^{-4} dilutions of lysates (10^8 plaque forming particles/ml.) by the agar layer method[3]; (*b*) spotting a large drop of the corresponding dilution in the middle of the plate once the top-layer agar had set. Results are presented in Table 1. Discrepancies are observed in the host-range of phages as determined by the two methods. In many instances an area of lysis is present where the undiluted drop of lysate was placed, but the plaque-forming titre of the phage on the particular organism is zero. This effect, which is specific and reproducible, always extends the intra-species and often the inter-species host-range. Dilution of the lysate before application of the drop in these cases never results in the area of the drop containing individual plaques but simply in the disappearance of the entire lytic area. This phenomenon was investigated by mixing the phage and the organism at 37° C. After a period of 20 min. for adsorption, an aliquot was quickly centrifuged to clarity and the supernatant titrated on the host strain for unadsorbed phage. Simultaneously, another aliquot was titrated for viable bacteria and unadsorbed phage plus infective centres on both the organism under investigation and the host strain. All titrations were completed within 30 min. after mixing. Results of a typical experiment are presented in Table 2. Abortive infection with killing of the organism provides an adequate explanation for the phenomenon. A similar phenomenon has been encountered with *Salmonella* and *Staphylococcus* phages[6], and in this laboratory with *Proteus* phages.

Table 2. Investigation of Phage 222 which Produces a Drop Area of Lysis on *L. casei* 316 without Individual Plaque Formation. Adsorption 20 min. at 37° C.

Initial concentration *L. casei* 316	$7·0 \times 10^8$/ml.
Initial concentration of phage 222	$4·5 \times 10^8$/ml.
Multiplicity of infection	0·64
Free phage after adsorption	$5·8 \times 10^8$/ml.
Phage adsorbed (per cent)	98·7
Surviving bacteria	$3·6 \times 10^8$/ml.
Bacteria killed by phage infection (per cent)	48·6
Unadsorbed phage + infective centres on *L. casei* 316	0
Unadsorbed phage + infective centres on host *L. fermenti* 222	$1·0 \times 10^7$/ml.
Infective centres on *L. fermenti* 222	$4·2 \times 10^6$/ml.
Killed *L. casei* 316 not yielding progeny phage (per cent)	98·8

Results obtained by both methods of phage-typing serve to confirm some of the serological relationships encountered by Sharpe[7] and Sharpe and Wheater[8]. Thus *L. casei* phages 300 and 316 and *L. casei* var. *rhamnosus* phage 356 all act on different strains of *L. casei*, *L. casei* var. *rhamnosus* and *L. plantarum*. The former two phages also act on various *L. fermenti* strains. The serological relationship which was detected between *L. fermenti*, *L. casei* and *L. casei* var. *rhamnosus* strains may be mirrored in the fact that many of the *L. fermenti* phages also act on *L. casei* strains. Davis[9] includes *L. lactis* in his *L. acidophilus* group and Sharpe[7] found *L. brevis* and *L. lactis* to share a major antigenic component. It is thus of some interest to note that three *L. fermenti* phages acting on *L. brevis* strains also produce abortive infections in four homofermentative *L. acidophilus* strains. While Sharpe[7] has not indicated any serological relationship between the heterofermentative species *L. fermenti* and *L. brevis*, many phages isolated on the former lyse cultures of the latter.

It is too early to decide whether the extended host-range obtained for many phages by employing abortive infection will be desirable when a complete phage-typing scheme, comparable both in elegance and utility to those in use for *Salmonellae* and *Staphylococci*, is evolved for *Lactobacilli*.

This work is submitted with the permission of Prof. C. L. de Jager, honorary director of the Nutrition and Dental Health Research Group of the South African Council for Scientific and Industrial Research.

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Association of Pigment with the Cell Envelope of *Serratia marcescens* (*Chromobacterium prodigiosum*)

The characteristic red pigment of the bacterium, *Serratia marcescens*, is located within the cell. Recently[1] evidence has been presented demonstrating that disruption of the bacterial cell releases pigment that is bound to particles. However, the origin and location within the cell of the particles and associated pigment were not established. The present communication presents evidence that the particulate, pigmented material is associated with the cell envelope of the micro-organism.

The 'Nima' strain of *S. marcescens* was grown at 27° C. for 18 hr. on casein hydrolysate–yeast extract–agar medium[2]. The pigmented organisms were harvested, washed several times in distilled water, and then treated for 20 min. in a Raytheon model *DF* 101 sonic oscillator. Whole cells and large particles were removed from the treated material by centrifugation at 4,000 r.p.m. for 10 min. The supernate was centrifuged at 10,000 r.p.m. for 20 min. to collect cell envelope material. After this treatment both the sediment and supernate remained pigmented. An attempt was made to clarify the supernatant material by centrifugation at 40,000 r.p.m. for 2 hr. The slight amount of pigment remaining in the supernate following this procedure was precipitated by acidifying the fraction to *p*H 5·0 with 1 *N* hydrochloric acid. This treatment produced a flocculent, light red precipitate and a colourless supernate.

To study the possible association of pigment with cell envelope material, the acetylhexosamine and pigment content of the various sediments and the acid precipitate was measured. The preparations were lyophilized and 25 mgm. of the dried material utilized for the analyses. For hexosamine determinations, the precipitates were treated with lysozyme (400 μgm./mgm. dry material) at 37° C. for 30 min. Acetylhexosamine then was estimated by the Elson and Morgan procedure[3]. Pigment was extracted from the dried preparations by a modification of the alkaline method of Hubbard and Rimington[4], and the pigment concentration of the extract measured in a Klett–Sumerson colorimeter employing the number 42 filter. The same treatments also were applied to dried, whole-cell preparations.

Table 1 presents the results of these experiments. It is readily seen that the hexosamine and pigment values parallel each other. When the hexosamine content is low, so is the amount of pigment, and vice versa. The greatest values are obtained in the 10,000 r.p.m. sediment. Lysozyme treatment of whole cells released some hexosamine, but the amount was almost doubled in the 10,000 r.p.m. material. Similar experiments carried out with colourless cells grown at 38° C. also demonstrated that the greatest concentration of hexosamine was present in the 10,000 r.p.m. sediment. Electron microscopy of the 10,000 r.p.m. fraction showed that the material consisted of many cell envelopes and unidentifiable cell debris with only a very occasional whole cell.

Table 1

Preparation	Pigment	Acetylhexosamine
Whole cells	35	5·11
4,000 r.p.m. sediment	73	6·79
10,000 r.p.m. sediment	151	9·04
40,000 r.p.m. sediment	58	5·71
Acid precipitate	20	0·56

Pigment concentration is expressed as Klett units; hexosamine, as μgm./mgm. dry material.

The results suggest that hexosamine and pigment are present in the same cellular structure. This structure is released by rupture of the cell, and can be collected in greatest quantity in the 10,000 r.p.m. sediment. The cell envelope is such a structure. It has been repeatedly established that the cell envelope contains acetylhexosamine, which can be released by lysozyme treatment[5,6]. The fact that the cell fraction containing the greatest concentration of acetylhexosamine also contains the most pigment suggests strongly the association of the two substances with the cell envelope. The electron microscopic pictures support this conclusion. Additional experiments in which cell envelopes were prepared by the procedures of Salton and Horne[7] and Kandler *et al.*[8] have confirmed that the pigment is associated with cell envelope material. Spectroscopic examination of the 10,000 r.p.m. sediment and cell envelope preparations demonstrated the absence of nucleic acid or other material absorbing at 260 mμ. As pointed out by Work[9], lack of these substances is characteristic of purified cell envelopes.

Few investigations have been carried out to determine the intracellular location of bacterial pigments. Salton[10] has described the pigment of *Rhodospirillum rubrum* as being in the cell wall; but Hickman and Frenkel[11] doubt this observation. The latter investigators suggest that the observation was based upon an incomplete removal of protoplasmic constituents from cell wall fragments. Recently, Mathews and Sistrom[12] have localized the carotenoid pigment of *Sarcina lutea* in the cell or plasma membrane which, together with the cell wall, forms the cell envelope. Their evidence was based on visual and spectrophotometric examination of purified cell wall material, upon lysozyme preparations of whole cells, and on the enzyme content of disrupted cell fractions. From the results we have presented, we cannot determine whether the pigment is located in the plasma membrane or wall portion of the cell envelope. However, the fact that lysozyme treatment of whole cells results in the release of a clear supernate containing hexosamine suggests that the pigment might be located in the cell or plasma membrane.

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MISCELLANY

Expression of Concentrations of Solutions

It is becoming customary, in the descriptions of histochemical methods, to express the concentration of solutions in terms not of percentage but of molarity. Thus, in one method, it is stated that a 0·004-*M* solution of lead nitrate should be used. Having eventually found a list of atomic weights and the formula of lead nitrate (it has, according to two textbooks, no water of crystallization) and then double-checked my addition, I discovered that in 100 ml. of distilled water I should dissolve 107·7 mgm. of lead nitrate.

But did the author use, as I obviously now do, a 0·1 per cent (0·003723 *M*) solution? If so, the term 0·004 *M* is inaccurate, time wasting and an example of scientific snobbery.

Surely it would prevent wasted effort and occasional inaccuracies if concentrations of solutions were expressed in terms not merely of molarity but also of percentage, particularly where the calculation of the percentage may prove troublesome.

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FORTHCOMING EVENTS

Monday, July 25

ROYAL SOCIETY (at the Royal Institution, 21 Albemarle Street, London, W.1), at 10.15 a.m.—Sir Arnold Hall, F.R.S.: "Trends in Aeronautical Science and Engineering" (Tercentenary Lecture).

INSTITUTE OF METALS (at the Royal Institution, Albemarle Street, London, W.1), at 6.30 p.m.—Prof. Linus Pauling (California Institute of Technology): "The Structure of Metals and Intermetallic Compounds".

Wednesday, July 27

SOCIETY FOR ENDOCRINOLOGY (at the Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W.1), at 5.15 p.m.—Prof. Bernardo A. Houssay (Buenos Aires): "An Argentine Trail in Hypophyseal Research" (Annual Lecture).

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURER, Grade B, TO TEACH EITHER MATHEMATICS OR PHYSICS to G.C.E. Advanced Level Standard—The Principal, Peel Park Technical College, Salford 5 (July 27).

SENIOR TECHNOLOGIST or TECHNOLOGIST (with H.N.C. or O.N.C. or appropriate City and Guilds qualification in telecommunications, and good experience on the maintenance and construction of electronic equipment and instrument maintenance) at the Nigerian College of Arts, Science and Technology—The Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2 (July 29).

ASSISTANT, Grade "B" (preferably with teaching and/or industrial experience) IN THE CHEMISTRY DEPARTMENT—The Principal, Wigan and District Mining and Technical College, Wigan (July 30).

ASSISTANT LECTURER (with a degree in chemistry, biochemistry or agricultural chemistry, preferably with honours) IN THE AGRICULTURAL CHEMISTRY DEPARTMENT—The Secretary, North of Scotland College of Agriculture, 41½ Union Street, Aberdeen (July 30).

LECTURER (graduate in science, preferably in physics, with suitable teaching experience) IN EDUCATION—The Registrar, King's College (University of Durham), Newcastle upon Tyne 1 (July 30).

LECTURER (preferably with an interest in, and practical experience of, hydraulics or soil mechanics) IN CIVIL ENGINEERING—The Registrar, The Manchester College of Science and Technology, Manchester 1 (July 30).

LECTURER (veterinary surgeon) IN THE DEPARTMENT OF VETERINARY PATHOLOGY, Royal (Dick) School of Veterinary Studies—The Secretary, The University, Edinburgh (July 30).

RESEARCH ASSISTANT (with a first- or upper second-class honours degree) in the Department of Agriculture (Crop Husbandry), to carry out sod-seeding experiments—The Registrar, University College of Wales, Aberystwyth (July 31).

SCIENTIFIC OFFICER (with at least a good honours degree in geography with subsidiary zoology and/or botany, or in zoology with subsidiary geography) IN THE GEOGRAPHICAL SECTION, for research in the biogeography of economically important locusts and grasshoppers—The Director, Anti-Locust Research Centre, 1 Princes Gate, Kensington, London, S.W.7 (July 31).

ASSISTANT LECTURER or LECTURER (with qualifications in mining geology or mineralogy) IN THE DEPARTMENT OF GEOLOGY—The Registrar, The University, Liverpool (July 31).

ASSISTANT LECTURER, Grade B, in BIOLOGY OR CHEMISTRY—The Principal, Peel Park Technical College, Salford 5 (August 2).

ASSISTANT LECTURER or LECTURER IN APPLIED MATHEMATICS—The Registrar, The University, Sheffield (August 3).

ASSISTANT BIOCHEMIST (with a degree or equivalent qualification in chemistry, experience in, or wishing to take up, clinical biochemistry)—The Secretary, Welsh National School of Medicine (University of Wales), 34 Newport Road, Cardiff (August 6).

LECTURER IN MECHANICAL ENGINEERING—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (August 8).

SENIOR LECTURER IN THE DEPARTMENT OF STUDIES IN PSYCHOLOGICAL MEDICINE—The Registrar, The University, Liverpool (August 13).

LECTURER IN EXPERIMENTAL PHARMACOLOGY—The Secretary of University Court, The University, Glasgow (August 15).

LECTURERS IN BOTANY, CHEMISTRY, EDUCATION, GEOLOGY, MATHEMATICS, PHYSICS AND ZOOLOGY at the University College of Townsville, University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, August 15).

RESEARCH FELLOW (with at least a good honours degree, and preferably qualifications in both physics and geology) at the University College of Rhodesia and Nyasaland, for a research project in palæomagnetism—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (August 16).

SENIOR LECTURER or LECTURER IN MATHEMATICS, and a SENIOR LECTURER or LECTURER IN PHILOSOPHY at Canberra University College, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, August 20).

ASSISTANT LECTURER or LECTURER (with special qualifications in either pure mathematics or applied mathematics) IN MATHEMATICS—The Registrar (Room 22, O.R.B.), The University, Reading (August 22).

LECTURER or ASSISTANT LECTURER (medically qualified or otherwise) IN THE DEPARTMENT OF PHYSIOLOGY—The Registrar, University College of South Wales and Monmouthshire, Cathays Park, Cardiff (August 22).

LECTURER IN CHEMISTRY at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, August 26).

SENIOR LECTURER IN BIOCHEMISTRY at the University College of the West Indies—The Secretary, Senate Committee on Colleges Overseas in Special Relation, University of London, Senate House, London, W.C.1 (August 29).

CHAIR OF EDUCATION—The Registrar, University College of Wales, Aberystwyth (August 31).

CHAIR OF PHILOSOPHY in the University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa and London, August 31).

LECTURER (interested in morphology and systematic botany) IN BOTANY—The Registrar, The University, Hull (August 31).

SENIOR LECTURER IN THE DEPARTMENT OF MATHEMATICS, University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa and London, August 31).

SENIOR LIBRARY ASSISTANT (graduate with library experience) in charge of the Current Periodical Room of the University Library—The Librarian, The Main Library, The University, Birmingham 15 (August 31).

LECTURER (preferably candidate who is a general botanist with research experience in more than one branch of botany) IN BOTANY at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, September 2).

READER IN CHEMICAL CRYSTALLOGRAPHY at Imperial College—The Academic Registrar, University of London, Senate House, London, W.C.1 (September 14).

CHAIR OF MEDICINE at Makerere College, The University College of East Africa—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (September 15).

CHAIR OF PSYCHOLOGY at Birkbeck College—The Academic Registrar, University of London, Senate House, London, W.C.1 (September 16).

ADMINISTRATIVE ASSISTANT (with a language qualification) IN THE SECTION OF INTERNATIONAL RELATIONS, principally for information bureau duties—The Assistant Secretary, The Royal Society, Burlington House, Piccadilly, London, W.1.

ASSISTANT LECTURER or LECTURER (preferably with an interest in climatology) IN GEOGRAPHY at the University College of Ghana—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1.

BIOCHEMIST, for an interesting research project—The Group Secretary, Rochdale and District Hospital Management Committee, Birch Hill Hospital, Rochdale, Lancs.

BIOCHEMIST (preferably with some experience of techniques applicable to muscle or nucleic acids), to assist in a study of the location of ribonucleic acid in muscle by autoradiography—Mr. D. K. Hill, Postgraduate Medical School of London, Ducane Road, London, W.12.

BIOLOGIST (preferably 25–35, with experience and interest in lower organisms, particularly protozoa) for collaboration in a programme of research on fine structure, function and morphogenesis—The Director, Medical Research Council Biophysics Research Unit, King's College, Strand, London, W.C.2.

COMPUTER, to work in a small team concerned with interesting research on thermonuclear processes—Prof. D. Gabor, F.R.S., Electrical Engineering Department, Imperial College of Science and Technology, London, S.W.7.

D.S.I.R. RESEARCH STUDENT (honours graduate in physics or electrical engineering) IN THE DEPARTMENT OF ELECTRONICS, for research into problems associated with microwave generation, electrical noise, electron spin resonance and nuclear magnetic resonance—The Professor of Electronics, The University, Southampton.

LECTURER or ASSISTANT LECTURER IN CHEMISTRY—The Registrar, Massey Agricultural College (University of New Zealand), Palmerston North, New Zealand.

LECTURER or SENIOR LECTURER (with a university degree in medicine, and preferably with an interest in applied pharmacology and therapeutics) IN PHARMACOLOGY—The Secretary, Charing Cross Hospital Medical School, 62–65 Chandos Place, London, W.C.2.

LECTURER (registered medical practitioner, with some experience of general pathology) IN THE DEPARTMENT OF NEUROPATHOLOGY—Prof. W. Blackwood, Institute of Neurology, The National Hospital, Queen Square, London, W.C.1.

RESEARCH ASSISTANT (with a first degree of the University of London and an interest in ultrasonics and electronics) IN ULTRASONIC PHYSICS—The Principal, Kingston Technical College, Fassett Road, Kingston-upon-Thames, Surrey.

RESEARCH BIOCHEMIST (with good training in physical chemistry and preferably a knowledge of food technology of fruits and vegetables)—Dept. 4240, National Employment Service of Canada, 61 Green Street, London, W.1.

RESEARCH FELLOW (preferably with experience in crystal or solid-state physics or in the physics of aerosols) IN EXPERIMENTAL PHYSICS, to work in a group investigating the basic physics of cloud and rain-forming processes—Dr. B. J. Mason, Huxley Building, Imperial College of Science and Technology, Exhibition Road, London, S.W.7.

SCIENTIFIC DIRECTOR (with three years post-doctoral research experience in nuclear reactions) OF THE NUCLEAR PHYSICS LABORATORY of the Institute of Physics and Mathematics, to lead research around an operating 800-kV. Cockcroft–Walton accelerator and to lecture on experimental and theoretical nuclear physics at the School of Physics at the University of Chile—Director, Instituto de Física y Matemáticas, Universidad de Chile, Casilla 2777, Santiago, Chile.

TUTORIAL ASSISTANT (man or woman graduate) IN MATHEMATICS—The Registrar, The University, Leicester.

REPORTS and other PUBLICATIONS

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Great Britain and Ireland

Mathematics, Education and Industry: a Record of a Conference of Teachers, Research Scientists, and Industrialists, held at the University of Liverpool, April 1959. Pp. 156. (London: *Technology*, The Times Publishing Company, Ltd., 1960.) 7*s*. 6*d*. [294

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